Technical Session - Tea Technology and Value Addition

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Oral Session

Poster Session

Impact of good agricultural practices on technical efficiency of Tea small holders

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Introduction

Tea is pre-eminent among Sri Lanka's plantation crops and it is one of the most important industries in the country in terms of employment and foreign exchange earnings. Sri Lanka's tea small holders, who account for 76% of the national tea output, are the mainstay of Sri Lanka's tea industry, are facing some serious problems like increasing cost of production and reducing marginal profits that will directly contribute towards reducing the national tea output in the future. However, given the high cost of production, there is a belief that it is very difficult to increase profitability without increasing costly inputs (Basnayake *et al*., 2002). Good Agricultural Practices (GAPs) addresses environmental, social and economical sustainability and often in combination with effective input use, is one of the best ways to increase smallholder productivity without costly inputs (Poisot *et al*., 2004). Having identifying the importance of GAPs in tea industry, this study was conducted to find out the impact of GAP adoption on technical efficiency of tea small holders in Sri Lanka

Methodology

84 tea small holders were selected as the sample, among tea small holders in Kuruvita DS Division using multistage sampling. Four TI ranges (Wewalwaththa, Erathna, Eheliyagoda and Kiriella) in Kuruvita were selected and 21 tea small holders were selected from each TI range.

Data collection was carried out by using structured questionnaire. The questionnaire includes two basic parts, part one is consisted basic inputs to measure technical efficiency and other part is used to collect data to find about the adoption level of tea small holders to Good Agricultural Practices on tea cultivation. To measure GAP adoption level questions were prepared under 14 GAP principles specifically to tea cultivation as recommended by Tea Research Institute (Zoysa, 2008).
Stochastic Frontier Production model was used to measure the technical efficiency. STATA statistical package, Minitab software and Microsoft Excel were used to data analysis.

$$\text{GAP Adoption Level} = \frac{\text{Number of GAP principles adopted by TSH}}{\text{Total GAP Principles}} \times 100 \quad (1)$$

GAP adoption level was measured using above equation for each TSH. Two empirical models were used to measure the factors affect production and to measure technical efficiency.
One of the empirical models is Cobb-Douglas function. In our calculation variables are explained by following Cobb-Douglas equation

$$lnY_{it} = ln\beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + \beta_6 lnX_6 + U_{it} \quad (2)$$

Table 1: Description of variables for Cobb-Douglas model

Notation	Name of Variable	Remarks
$\boldsymbol{lnY_{it}}$	Log value of total green leaves	Kg
$\boldsymbol{ln\beta_0}$	Parameter for intercept of regression line	None
$\boldsymbol{ln\beta_1 X_1}$	Log of tea land extent	Acres
$\boldsymbol{ln\beta_2 X_2}$	Log of family labor	Hours
$\boldsymbol{ln\beta_3 X_3}$	Log of hired labor	Hours
$\boldsymbol{ln\beta_4 X_4}$	Log amount of fertilizer	Kg
$\boldsymbol{ln\beta_5 X_5}$	Log amount of agrochemicals	Rupees
$\boldsymbol{ln\beta_6 X_6}$	Log amount of Dolomite	Kg
$\boldsymbol{U_{it}}$	Stochastic Error term	None

The other empirical model used was Technical Inefficiency Function. A technical inefficiency effect was defined Battesse and Coelli (1995) and explained according to that explanation.

$$U_i = Z_i\delta + W_i \qquad (3)$$

$$i = 1,2, \ldots \ldots, N$$

U_i is technical inefficiency, Z_i is the vector of explanatory variables associated with the technical inefficiency effect, δ is the vector of unknown parameter to be estimated and W_i is unobservable random variables.

In the model specification,

$$U_I = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} + W_i \qquad (4)$$

Table 2: Inefficiency Variables

Notation	Inefficiency Variables	Unit
$\boldsymbol{Z_1}$	Age of the farmer	In years
$\boldsymbol{Z_2}$	Education of the farmer	In years
$\boldsymbol{Z_3}$	Occupation of the farmer	Dummy, if tea only = 1, otherwise=0
$\boldsymbol{Z_4}$	Gender	Dummy, if male=1, female=0

Z_5	Experience in tea cultivation	In years
Z_6	Age of plantation	In years
Z_7	Trainings	Number of times attend
Z_8	Membership of association of TSH's	Dummy, if member=1, nonmember=0
Z_9	Adoption level to GAP	In percent

Results and discussion

This section summarizes the descriptive statistics of the data and the outcome of the empirical models used to analyze the data. Following table shows summery statistics of GAP adoption level of TSH in the area.

Table 3: Summery Statistics of GAP adoption level

Respondents	Mean	StDev	Median	Minimum	Maximum
N= (84)	55.57	8.754	56	22	72

Source: Minitab 14 analysis of survey data

There were past studies which have measured adoption levels according to the number of practices respondents have adopted (Bang, 2012; Boz I, *at el* 2011). In my study also I used the number of GAPs TSHs have adopted and divide them into two levels as adaptors and non adopters.

Sample was divided to GAP adopters and non adopters. 43 TSHs who scored 56 or more was grouped as GAP adopters and 41 TSHs who scored below 56 are grouped as GAP non adopters.

The maximum likelihood estimates of the parameters of the stochastic frontier production function are presented in Table 4. The estimate of Γ is 0.926, which indicates that the majority of error variation is due to the inefficiency error Ui. (and not due to the random error Vi). This indicates that the random component of the inefficiency effects does make a significant contribution in the analysis.

Table 4: Estimates of the Stochastic Frontier Production Function

Variable	Coefficient	Std. Err	Z	$P > \|Z\|$
Land extend	0.966147***	0.0813178	11.88	0.000
Family labour	0.045638***	0.0156336	2.92	0.004
Hired labour	0.0419136**	0.0189145	2.22	0.027
Fertilizer	-0.0026291	0.030904	-0.09	0.932
Chemicals	-0.027902**	0.012909	-2.16	0.031
Dolomite	-0.0193065	0.017832	-1.08	0.279

Cons	8.671964	0.248668	34.87	0.000
σ^2	0.5071351			
Γ	0.9262876			
Log likelihood	-48.618234			

** Significant at 10 % ** Significant at 5 % and *** Significant at 1 %*

Source: from STAT version 11 analysis of survey data

Maximum likelihood estimates of the stochastic frontier model were estimated for green leaf yield as a function of land extend, family and hired labour, fertilizer, agrochemicals and dolomite, using Cobb-Douglas model. Land extend, family labour and hired labour showed significant effect on yield in a positive way, chemicals also were showed a significant effect but in a negative way.

According to Summery Statistics of Technical Efficiency from STATA version 11, mean technical efficiency of TSH in Kuruvita is 63.17

Table 5: Determinants of inefficiency Cobb-Douglas model

Variable	Parameter	Coefficient	Std Err	p value
Age	δ_1	0.0321381	.0263658	0.223
Education	δ_2	-0.0130145	.126756	0.918
Occupation	δ_3	0.0596928	.4865421	0.902
Gender	δ_4	-1.016146**	.486411	0.037
Experience	δ_5	-0.049053	.0327829	0.135
Age of plantation	δ_6	0.0268849	.0411904	0.514
Trainings	δ_7	0.1533232	.1161482	0.187
Membership of associations	δ_8	-0.1328316	.5093004	0.792
GAP Adoption	δ_9	-0.12193***	.030065	0.000

** Significant at 10 % ** Significant at 5 % and *** Significant at 1 %*

Source: STAT version 11 analysis of survey data

Gender and GAP adoption level has significant effects on technical inefficiency. The coefficient for GAP adoption level is -0.12193 and significant at 1% level on technical inefficiency.

Conclusion

Knowledge of TSH's about GAP'S are not in a satisfactory level in this area. The results obtain of the stochastic frontier estimation revealed that, average technical efficiency of TSH's in Kuruvita given by the Cobb- Douglas model is 63.18 per cent. Therefore there is a scope of further increasing output by 36.82 per cent without increasing the level of inputs. From the factors considered which affect technical efficiency, gender of farmer and GAP adoption affect significantly at 5% and 1% levels respectively.

Male TSHs appeared to be more technically efficient than females. This may be due to male TSHs have more contact with society around them, specially with other tea small holders than typical Sri Lanka women in village. Sri Lankan women have more responsibly on house hold work than men, so they have less time to spent in farming may be another reason.

GAP adoption is positively significant at 1% level with technical efficiency. Mean technical efficiency of GAP adopted famers shown to be 71.9% while 54.1% for non adopters. As the definition says Good Agricultural Practices are practices that address not only environmental and social sustainability but also it addresses economic sustainability. By adopting GAPs TSHs can increase their technical efficiency.

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Factors affecting on tourists’ buying behavior of Ceylon Tea

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Introduction

Worldwide tea production and consumption have increased over the past decades. According to statistics provided by the Sri Lanka Tea Board, Sri Lanka is the 3rd largest exporter and the 4th largest producer of tea in the world (Sri Lanka Tea Board 2011). However, Sri Lanka still continues to retain its position as the main source of orthodox black tea in the world with the image of Ceylon tea enhanced by its unique specialty character.
Meanwhile, Sri Lanka is one of very attractive destinations among the tourists all over the world. Sri Lanka Tourism has boomed to a new milestone of one million arrivals in 2012, which is an all-time high figure in the history of the country (Sri Lanka Tourism Development Authority 2012). Ceylon tea attracted a whole new group of customers who were traditionally non-customers in the industry. Times are fast changing, and the people are no longer looking for the cheapest beverages. They are moving away from low quality tea to a quality product. With this background Ceylon tea is being popular among tourists coming to Sri Lanka.

The local value added tea market is led by multinational players and small holders. All of these brands cater to low and middle income category consumers, who purchase tea for value for money. In addition to these players, there are plenty of small time cottage tea players who sell unbranded/loose tea (Prematunga 2009). Merely a few brands are targeting this consumer segment currently. Such brands also have no idea about tourists buying behavior of Ceylon tea.

Consumer buying behavior has been always of great interest to marketers. The knowledge of consumer behavior helps the marketer to understand how consumers think, feel and select from alternatives like products and brands and how the consumers are influenced by their environment, the reference groups, family, and salespersons and so on. The consumer’s buying behavior is influenced by many factors. Most of these factors are uncontrollable and beyond the hands of marketers. An important marketing implication is that there is a growing demand to understand tourists’ buying behavior in Sri Lanka. Particularly in the context of Ceylon tea this is sort of significant. Understanding the tourists’ buying behavior of Ceylon tea is truly significant to the increment of sales and it functions as an indirect communication tool as well. However, despite its obvious importance, there appears to be a serious lack of formal understanding of tourists’ buying behavior by both academics and practitioners. Thus, there is an immediate need of systematic research and scientific understanding of this topic.

Methodology

Data were collected through a survey by giving a structured questionnaire to 160 tourists who bought Ceylon tea from three tea centers located in Kandy district. Judgment sampling technique was used to select Kandy as the location of the study since it is one of the major tourist destinations in Sri Lanka. Further, Kandy is known as the most famous city among tourist for Ceylon tea. Among all the identified tea outlets in Kandy district, four tea centers were selected using random sample method. Data was collected from consumers on the basis of first come, first served (FCFS).
Primary data was collected through a self-administered questionnaire among the tourist consumers of Ceylon tea. The questionnaire was consisted of three sections. Section 01 was consisted questions

regarding demographic variables such as country, gender, age, education level and number of family members. These questions helped to express a simple overview of the sample.

Section 02 was consisted 23 questions regarding independent variables which assume to be affected for tourists' buying behavior of Ceylon tea. These questions prepared for gathering data about Product factors, Motivational factors, Promotional factors, Legal factors, Travelling factors, Awareness and attitudes of Ceylon tea and past experience with Ceylon tea. All those questions were created based on Five Point Likert Scale in order to identify how these predicted factors affect to Ceylon tea buying behavior. The Likert scale was ranging from strongly agree (SA) to strongly disagree (SD).

Section 03 was consisted only one question regarding the amount spending for Ceylon tea by tourist consumers. This question prepared for gathering data about how much money they had spent for Ceylon tea during the journey.

Data were analyzed using IBM SPSS Statistics 20 software and Microsoft excel 2013 software version. Descriptive statistical techniques were used to discover and summarize the attributes of the sample and it was provided descriptive information such as mean, mode, median and standard deviation of the studied sample. Correlation coefficient and multiple regression analysis revealed that how predicted factors effect on tourists' buying behavior of Ceylon Tea.

Results and Discussion

According to the descriptive statistics of the study the "mean" of promotional factor has fallen under the range of $3.5 <= X < 5$.This illustrates that all the participants almost agree with the existing situation of promotional factors in Ceylon tea purchasing. However, participants are moderately agreed with six independent variables. They are Attitudes of Ceylon tea, Awareness of Ceylon tea, Experience with Ceylon tea, Legal factors, Motivational factors and Product factors. The "mean" value of all these input variables have fallen under the range of $2.5< = X < 3.5$. The "mean" value of Travelling factor has fallen under the range of $1 < = X < 2.5$. This mean value implies that tourist customers almost disagree with travelling factors in tea purchasing.

Table 1: Mean and Standard Deviation of Input Variables

Variable	**Mean**	**Std. Deviation**
Attitudes	3.3703	0.92738
Awareness	3.0766	0.96438
Experience	3.1625	1.08528
Travelling Factors	2.1219	0.70877
Promotional Factors	3.5073	1.05461
Legal Factors	3.0563	0.86691
Motivational Factors	3.1398	0.70507
Product Factors	3.0438	0.92848

According to Correlation coefficient analysis, Attitude of Ceylon tea denotes a 0.725 amount of correlation with Amount of money spend which is suggested that there is strong positive relationship between independent variable Attitude of Ceylon tea and dependent variable Amount spend. As well as, Awareness of Ceylon tea (0.542) and Product factors (0.569) show strong positive relationship with dependent variable Amount spend.

Table 2: Correlation between factors and amount spends for Ceylon tea

Variable	**Pearson correlation**	**Relationship**
Attitudes	0.725	Strong positive correlation
Awareness	0.542	Strong positive correlation
Experience	0.483	Weak positive correlation
Travelling Factors	0.273	Weak positive correlation
Promotional Factors	0.261	Weak positive correlation
Legal Factors	0.391	Weak positive correlation
Motivational Factors	0.483	Weak positive correlation
Product Factors	0.569	Strong positive correlation

According to the Multiple Regression Analysis of Predicted factors and Amount spends, Promotional factors (0.162), Travelling factors (0.120) and Legal factors (0.090) are P-Value is greater than the 0.05 therefore those elements are not significantly to the model.

Table 3: Multiple Regression Analysis of Predicted factors and Amount spends

Variables	Unstandardized Coefficients		Standardized	P- Value
	B	Std. Error	Beta	
(Constant)	-5176.471	824.660		**0.000**
Attitudes	1340.104	178.748	0.425	**0.000**
Awareness	511.563	158.525	0.169	**0.002**
Experience	313.763	129.388	0.116	**0.016**
Travelling Factors	301.710	192.778	0.073	0.120
Promotional Factors	180.796	128.525	0.065	0.162
Legal Factors	280.579	164.291	0.083	0.090
Motivational Factors	634.277	208.042	0.153	**0.003**

When consider Attitudes of Ceylon tea, the Beta coefficient of 0.425 indicates that when Attitudes of Ceylon tea was increased by one unit while other variables remain constant, amount of money spend was increased by 0.425 units. It can be seen that Assurance contributed significantly to the model since p-value of 0.000 is less than 0.05 level of significant.

When consider Awareness of Ceylon tea, the Beta coefficient of 0.169 indicates that when Awareness of Ceylon tea was increased by one unit while other variables remain constant, amount of money spend was increased by 0.169 units. It can be seen that Assurance contributed significantly to the model since p-value of 0.002 is less than 0.05 level of significant.

When consider Experience of Ceylon tea, the Beta coefficient of 0.116 indicates that when Experience of Ceylon tea was increased by one unit while other variables remain constant, amount of money spend was increased by 0.116units. It can be seen that Assurance contributed significantly to the model since p-value of 0.016is less than 0.05 level of significant.
When consider Motivational Factors, the Beta coefficient of 0.153 indicates that when Motivational Factors were increased by one unit while other variables remain constant, amount of money spend

was increased by 0.153 units. It can be seen that Assurance contributed significantly to the model since p-value of 0.003 is less than 0.05 level of significant.

When consider Product Factors, the Beta coefficient of 0.200 indicates that when Product Factors were increased by one unit while other variables remain constant, amount of money spend was increased by 0.200units. It can be seen that Assurance contributed significantly to the model since p-value of 0.000 is less than 0.05 level of significant.

By using above information, multiple linear regressions model can be articulated as follows.

$$\mathbf{AS = -\,5176.471 + 0.2\ PDF + 0.153\ MF + 0.169\ AW + 0.425\ AT + 0.116\ EX + \delta}$$

Conclusion

The first objective of this research was to identify the relationship between factors affecting on tourists' buying behavior of Ceylon tea. Correlation coefficient used to identify the relationship between predicted factors and amount spends for Ceylon tea. According to the results, Attitude on Ceylon tea, Awareness of Ceylon tea and Product factors have a strong positive relationship with Ceylon tea buying behavior but, travelling factors, legal factors, motivational factors, promotional factors and experience have weak positive relationship with Ceylon tea buying behavior of tourists.

The second objective of this research was to identify the impact of factors on Ceylon tea buying behavior. Multiple regressions analysis was used to identify the factors influence on Ceylon tea buying behavior. According to multiple linear regression test, Attitude of Ceylon tea, Awareness of Ceylon tea, experience of Ceylon tea, Product and motivational factors were significant under 95% significant level. All other factors weren't significant.

The third objective was to identify the most and least influencing factors on tourists' buying behavior of Ceylon tea. Among the eight factors, Attitudes of Ceylon tea has high correlation with amount spends for Ceylon tea. Therefore it's most important factor which is having high influence over to the Ceylon tea buying behavior. Further, Promotional factor has a least influence on tourists buying behavior of Ceylon tea.

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Determinants of Poverty in Tea Estate Workers in Nuwara Eliya District

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Introduction

As a developing country, poverty is a major issue in Sri Lanka. The poverty or poor is expressed as lack of access to basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education etc. The poverty line specifies the minimum standard of living condition in the society to which everybody should be entitled. However, income level and other facilities available to people in the different sectors may vary. Also, the household living standard has a strong relationship with the poverty of the people. NuwaraEliya district is one of the major tea growing areas in Sri Lanka. Of the total population in NuwaraEliya district (706,588), 53.6 % of the population is belonged to estate sector (Central Bank, 2013). Knowing the socio-economic factors which affect to poverty in estate sector is vital to find the strategies for improving their living conditions. Therefore, this study attempts to identify the determinants of poverty in estate sector. The results of the study will be useful to make policies and suggestions to improve their living conditions of estate workers in NuwaraEliya district.

Methodology

The present study was conducted in tea growing locations of NuwaraEliya district. There are five District Secretariat (DS) divisions in NuwaraEliya District and of them, NuwaraEliya DS division was purposely selected for the study, since the highest estate population is recorded in this DS division (Central Bank, 2013). Multi stage sampling method was used for the selection of tea estates and systematic sampling technique was used to select the respondents. Out of seventy two GramaNiladari divisions, four GramaNiladari divisions were randomly selected. An estate was randomly selected from each selected GramaNiladhari division. Fifty workers were selected from each estate for the survey and total sample size was 200 estate workers. Primary data relating to various parameters of socio - economic status were gathered through well designed and pre tested questionnaire. The secondary information was collected from various published/unpublished sources. Tabular and regression techniques were employed to analyse the data. Binary Logistic regression model was employed to identify the determinants of poverty.

A poverty level (poor or non - poor) was decided by using the real per capita expenditure as a cut off point corresponding to Sri Lanka Official Poverty Line (OPL) Rs. 3924 in 2014 August (Department of Censes and Statistic, 2014).

The Binary Logistic regression model could be expressed as

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \varepsilon$$

$$P(Y_i = 1) = \frac{exp\ (x_i\beta)}{1 + exp\ (x_i\beta)}$$

Where,

Table 01: Variable description

Variable	Variable Description
Y	Poor / Non poor household 1, Poor (if per capita household monthly expenditure < Official poverty line) 0, Non poor (if per capita household monthly expenditure > Official poverty line)
X_1	Household size (Number)
X_2	Gender of the household head 1, Male 0, Female
X_3	Dependency Ratio
X_4	Age of household head (Years)
X_5	Education level of household head 1, if the household head was illiterate 2, if household head had studied up to primary (Grade1-5) 3, if household head had studied up to middle (Grade 6-10) 4, if household head had studied up to secondary (Grade 11-13) 5, if household head had studied up to graduate and post graduate
X_6	Household Income (Rs. / Month)
X_7	Household daily calorie intake (Calories / day)
X_8	Number of occupant members in the household (Number)
X_9	Monthly household savings (Rs / Month)

X_{10}	Suffering from Chronic illness or disability within the household members 0, if yes 1, if no
β_0	Intercept term
$\beta_1 - \beta_{10}$	Coefficients of X1 – X_{10}
ε	Random error term

Results and Discussion

According results of the binary logistic regression (Table 02), gender of household head, education level of household head, household income and household daily calorie intake were the negative significant factors. That indicates these factors are negatively effect on poverty and positively effect on non - poor. However, household size was positive significant factor to the poverty. The negative coefficient of gender of household head (- 1.49) showed that tendency of female headed household to become a poor is high. The negative coefficient value of education level of household head (- 0.39), indicated that when the education level of the household head decreased, probability of becoming their family in to poor has increased. The coefficient associated with household income had a negative effect on poverty (- 0.000042). It indicated that when the household income was reduced they cannot fulfill their basic needs and wants, therefore the family become a poor family. The coefficient of household daily calorie intake was also negative (- 0.000150). It means that when the family members did not get their daily recommended nutrient allowance they are poor. The positive coefficient associated with household size is (0.72). Hence when household size increases, the poverty also increased.

Table 02: Parameter estimates for binary logistic regression

Variables	Coefficient	P > Z	Exp (β)
Household Size	0.723360***	0.000	2.061
Gender of Household Head	-1.497702	0.083	0.224
Age of household head	-0.035240	0.113	0.965
Education level of household head	-0.399094***	0.009	0.671
Dependency ratio	0.001365	0.628	1.001
Household income	-0.000042**	0.016	0.999

Household daily calorie intake	-0.000150***	0.005	0.999
Household members suffering chronic illness or disability	0.177778	0.619	1.195
Constant	2.507769	0.151	12.278

Note: significant levels denoted as *** $P < 0.01$ (1%) ** $P < 0.05$ (5%) * $P < 0.1$ (10%)

Conclusion

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \varepsilon$$

According to the results household size, gender of the household head, education level of the household head, household daily calorie intake and household income are directly influenced to the poverty in estate workers. These results indicate that large families are more tend to be poverty. Awareness creation on family planning will go a long way in reducing the household size of the estate households since there is tendency of being poor with large household size. Most of the estate workers always eat less number of food groups and their diet diversity was less therefore the awareness program should be conducted to increase workers knowledge about food consumption pattern. And also awareness program should be conducted to the parents, about importance of the education. More attention should be given to the above factors when designing poverty alleviation programmes to the estate workers in the NuwaraEliya district. The findings of the study will be useful to the government when make policies for poverty alleviation programmes in the study area.

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Remittance and investment of Tea small holders in Uva region

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Introduction

Labor shortage is a current problem facing by tea small holding sector. The predominant reason for that is migration of workers from out of farming. These migrants send remittance to their households. Societal perception about labor migration is that it has a negative impact on the sustainability of the tea small holding sector. But, there might be some positive impacts from remittance gained by the migrants especially as investments on tea lands. Hence, it is very much important to understand the ability to compensate the labor shortage by the remittance sent by the migrants. According to Chen (2004), Migrants are defined as those who lived away from their families for migratory work for no less than one month.As well as Migrant familiesspecifically refer to those rural families in which at least one family member is identified as migrant.Money and goods that are transmitted to households back home by people who working away from their origin community (Adams, 1989).

Methodology

The population of the research was the total tea small holders in Uva region. There are 16 TI ranges under 3 main sub offices in Uva region. (Annual Report 2012, Tea Small Holding Development Authority). Multistage sampling method was used for the selection of the tea small holder's household units. There are three sub offices in Uva region as Haliela, Bandarawela, Welimada. There are six ranges of Haliela sub office, six ranges of Bandarawela sub office and four ranges of Welimada sub office. Three ranges each from Haliela and Bandarawela sub offices and two ranges from Walimada range were randomly selected. 100 Tea small holders were randomly selected from these 8 TI ranges. Primary data were collected from the farmers while they were interviewed at their field or their residences. Productive investment for tea land was the dependent variable of this study. It was measured calculating all the expenses for tea land within past twelve months. The expenditure for, Buying new tea land, Infilling the tea land, Fertilizer application, Soil conservationmeasures, Shade tree management, Pest and disease management , Within last twelve months. Household characteristics, characteristics of household head and socio economics characteristics were used as independent variables. There are thirteen independent variables as Age of house hold head, Education Level of household head, Tea cultivated land extent, Number of children, Income from Tea land, Durable consumption, Non-durable consumption, Other Investment, Migration Dummy, Remittance, Income from Other Cultivation, Income from Job of household head, Number of family members. Data were analyzed by Using Stata software package. Descriptive statistical techniques were used to present the demographic features of the sample. Multiple linear regression analysis was worked out to find out the impact of remittance on productive investment of Tea small holders in Uva region.

$$\mathbf{InvT = \beta_0 + \beta_1AH + \beta_2Edu + \beta_3Land + \beta_4NOFM + \beta_5NOC + \beta_6InT + \beta_7InOC}$$

$+ \beta 8InJ + \beta 9Dura + \beta 10NDura + \beta 11OIn + \beta 12MigD + \beta 13Rem + \varepsilon i$

(InvT - productive investment for tea land, β_0 – Constant, β_0 to β_{13} – Coefficient, εi – Error)

Results and Discussion

Regression analysis were used to quantify the relationships between variables to achieve the objectives more precisely.

According to the results of the multiple regressions, coefficient value for each variable has given below.

Notation	**Description**	**Coefficient**
Land	Tea cultivated land extent	-323.5198
NOFM	Number of family members	7835.633**
AH	Age of household head	-465.2015
Edu	Education Level of household head	6778.881**
NOC	Number of Children	-7102.874***
InT	Income from tea land	1.6452*
InOC	Income from Other Cultivation	0.423728
InJ	Income from job of household head	0.3829989
Dura	Durable consumption	-0.0663617**
NDura	Non-durable consumtion	-0.2829667
OIn	Other Investment	-0.436204
MigD	Migration Dummy	-18314.91***
Rem	Remittance	3.706997*
Cons		-6835.742

[Note: * $p< 0.01$(99% confident interval), ** $p< 0.05$ (95% confident interval), ***$p< 0.1$ (90% confident interval)]

Independent variables which are giving high P- value less than 0.05 and 0.1, can be included to the regression equation as follows,

$$\textbf{InvT} = -6835.742 + 6778.881\textbf{Edu}^{**} + 7835.633\textbf{NOFM}^{**} + 1.6452\textbf{InT}^{*} + (-.0663617)\textbf{Dura}^{**} + (-18314.91)\ \textbf{MigD}^{***} + 3.706997\textbf{Rem}^{*} + (-7102.874)\ \textbf{NOC}^{***}$$

The results of regression analysis shows that education level of household head, number of family members, income from tea land, durable consumption, migration of family members, remittance and number of children were the significant factors affecting on productive investment on tea land. Education Level of household head has a positive effect on productive investment for tea lands. Therefore having a profound sound education standard of household will lead to increase the productive investment. Numbers of family members have positive significant effect on the productive investment on tea land. It reveals that when the numbers of family members are increase, the productive investment on tea land will be increased. Income from tea land has positive significant effect on the productive investment on tea land. It explained that when income of the tea land is increased the productive investment also can be increased. Durable consumption has negative significant effect on the productive investment on tea land. It suggests that when increase durable consumption; productive investment on tea land will be decreased. There is a negative relationship between number of children and productive investment for tea land. Itexplained that when number of children is increased, productive investment on tea land will be decreased. Migration dummy variable has negative significant effect on the productive investment for tea land. It revealed that when labours migrate to another area out of farming, productive investment on tea land will be decreased. Even migration has negative impact on productive investment on tea land, remittance variable has positive significant effect on the productive investment on tea land. It reveals that when the possibility of remittance is increased, the productive investment on tea land will be increased.

Conclusion

There is a significant impact of remittance gained by migrant on productive investment in tea land In Uva region among tea small holders. With increasing of remittance gained by migrants the productive investment in tea lands also increasing can be identified. My findings also imply that migrant remittances can compensate for the loss of labor in agricultural production from out migration of labours.

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Awareness and adoption of recommended technologies and management practices by the Tea small holders

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Introduction

Tea (*Camellia sinensis*) is the world famous beverage next to the water and having numerous health and socio economic benefits. Tea, the prominent crop of the plantation sector in Sri Lanka, grows in many parts of the country (Mendis, 1992).Tea growers who have lands less than 10 acres in extent are treated as "Tea small holdings" according the Tea Control act. The cultivation of tea is attractive to small farmers because tea provides work and income throughout the year, requires relatively little investment, and the risk of complete crop failure is small (Annual Report, Tea Small Holdings Development Authority, 2012).As well as the Contribution of small holders to the Sri Lankan tea sector is higher than the plantation sector and it is account for 71.4 % of the national tea output (TSHDA, 2012). Therefore, application of scientific agricultural knowledge and technology adaptation in the small holding tea sector is a vital investment to enhance the productivity and overall performance of the tea industry.

Materials and methodology

Data were collected through a sample survey by giving a structured questionnaire to 8 tea inspector's (TI) ranges at Badulla administrative district and 150 small holders were randomly selected as the respondents. The questionnaire was mainly formulated to identify the awareness, level of adoption, and factors affecting to the level of adoption. The awareness was measured by percentage of aware respondents. The adoption level was measured by using "Adoption index" and "Confident interval method". Adoption index was categorized in to three levels as low adoption, medium adoption and high adoption. To identify the factors affecting to level of adoption, regression analysis was conducted and "Adoption on Technology and recommended practiced" has been taken as the dependent variable and data were collected for dependent variable under five categories as Machinery usage, Planting materials, Field practices, Recommended tests and Extension services. For the independent variables data were collected under nine categorical variables as Gender, Age level, Education Level, Source of Income, Experience with Tea land, Land ownership, Land extent, Time spending with tea land and Yield.

Data were analyzed using SPSS Software package and MS-Excel 2010 package. Descriptive statistics were done to analyze the independent variables and by using regression and correlation analysis factors affecting to the level of adoption was analyze and their strength was measured.

Results and Discussion

According to the study only 26 % of respondents have the awareness regarding machinery usage in tea plucking and from them, 48.7 % belongs to year 40 – 50 age group. 79.3 % of the respondents have awareness regarding the improved varieties. According to the study 64.7 % of the respondents have an awareness regarding recommended tests like pH test, starch test which use at the field. Extension services have been accounted under two categories as consulting services and E-consulting services and according to the study 100 % of the respondents have an awareness on consulting services while 36 % of the respondents have awareness on E-consulting services. According to the results of the study it shows that awareness on shade trees, pruning methods and soil conservation methods are respectively 95.3 %, 90.3 % and 93.3 %.

Level of adoption was calculated using Adoption index and confident interval method. Data were collected under five categories and finally overall adoption level for the recommended technology and management practices was calculated.

Table 1: Level of Adoption on Recommended Technologies and Management Practices

Statement	**Adoption Level**		
	Low Adoption	**Medium Adoption**	**High Adoption**
Machinery Usage	71.3 %	0	28.7 %
Improved Planting Materials	58.7 %	0	41.3 %
Field Practices	26.7 %	30 %	43.3 %
Recommended Tests	44.7 %	0.7 %	54.6 %
Extension Services	39.3 %	18 %	42.7 %
Overall Adoption on Recommended Technology and Management Practices	**38 %**	**9 %**	**53 %**

According to the Table 1, it clearly shows a lack of adoption on machinery usage in tea fields and usage of improved planting materials for the tea fields by small holders. But when we consider about the adoption level on field practices, recommended tests and extension services respectively 43.3 %, 54.6 % and 42.7 % are belong to high adoption level. After analyzing all factors 53 % of tea small holders in Badulla district show high adoption on recommended technologies and management practices while 38 % and 9 % respectively show low adoption and medium adoption.

Regression analysis was conducted to identifying the factors affect to the level of adaptation on recommended technologies and management practices. Mainly there were nine factors have been considered as independent variables. According to the results of the regression analysis Gender (0.000), Age level (0.009), Education level (0.043), Experience with Tea land (0.001) and Land extent (0.001) gave significant effect on level of adoption on recommended technologies and management practices under 0.05 significant level with the 67.9 % of R^2value.

After that to identify the relationship between level of adaptation and factors affected on level of adaptation, Correlations analysis was conducted.

Table 2: Results of the Correlation Analysis with Level of Adoption

Independent Variables	Correlation Co-efficient	Status of Correlation
Gender	-0.661	Strong Negative Relationship
Age	-0.251	Week Negative Relationship
Education Level	0.304	Week Positive Relationship
Experience	-0.313	Week Negative Relationship
Land Extent	0.451	Week Positive Relationship

Results of the Table 2 show that there is negative relationship of Gender, Age level and Experience with tea land while Education Level and Land extent show positive relationship. The negative relationship of gender is due to male is given "1" and female is given "2" at the analysis. The negative relationship of the age level shows that the youngers have more adopted on recommended technologies and management practices than elders. It may be elders are not willing to shift from their traditional methods. As well as when farmers older their experience is also high. There for the experience with the tea land also have given the negative relationship. Education level has given a positive relationship with the adoption. It may due to high educated people more likely to use new technology than others and they have more access to reach for technologies. Land extent also shows the positive relationship with the technology usage. It may due to people use technology for larger lands than small lands.

Conclusion

According to the research it is revealed that there is a good awareness on recommended technologies and management practices by the small holders. But there is a lack of awareness regarding usage of plucking machineries as 26 % and the usage of E – Consulting services (36%). When we consider about the adoption level of small holders, majority of small holders (53%) have high adoption level on recommended technologies. For the above adoption levels, Gender, Age level, Education level, Land extent and Experience is affected. Land extent and Education level positively affect while Gender, Age level and Experience affecting negatively.

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Analysis of factors affecting for Tea buyers' level of trust on Tea brokers

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Introduction

The tea industry in Sri Lanka has paramount importance to country's economy. In Sri Lanka, out of total quantity of bulk packaged tea, more than 95% is sold through public auction annually. The main participants of auction system are buyers and brokers. The most important concept, to carry out the business relationship between buyers and brokers is TRUST. All the transactions between buyers and brokers will confirm with the trust before complete the transaction by using monetary terms. In economic terms, trust can be defined as "the belief or perception by one party (e.g. a principal) that the other party (e.g. an agent) to a particular transaction will not cheat" (Paul J. Zak and Knack, 2001). In the case of buyer-broker relationship in the tea industry (relevant to buyers), trust can be defined as a belief of the buyer that the broker will efficiently provide good quality teas without any deceptions, while maintaining the goodwill. Therefore this research was carried out to identify major factors affecting for tea buyers' trust on tea brokers.

Methodology

The selected population for the study was all the tea buyers who are weekly buying tea at the Colombo Tea Auction. The data were collected from a sample of 70 tea buyers selected using Simple Random Sampling technique and ranked according to their export quantity (Sri Lanka Custom Data, 2012).

Data were collected through a questionnaire by individually giving it to the selected sample. The trust was measured by using ten point likertscales. Data were analyzed using Descriptive Statisticsmanner andbased on Ordinal Logistic Regression analysis techniques.Ordinal Logistic Regression is used to predict an ordinal dependent variable given one or more independent variables(ChristensenR.H.B.,2011). The SPSS statistical software, Minitab 16 software and Microsoft Excel were used for both descriptive and ordinal logistic regression analysis.

Result and Discussion

Following empirical model was developed to determine the factors affecting for buyers' trust on brokers.

$$Y_j=\alpha_j+\beta_1 RC+ \beta_2 RP+ \beta_3 CS+ \beta_4 CON+\beta_5 COM+\beta_6 EX +\beta_7 IR+\beta_8 ES+\varepsilon$$

Where, j = from 1 to the number of trust levels minus 1 = 1 to 9, α_j = Intercept of j^{th}threshold level (threshold coefficient), β_1 to β_8 = coefficient, RC=Relationship Continuity, RP= Reputation, CS=Conflict Solving, CON=Confrontation, COM=Communication, EX= Experience in the industry as a individual person, IR=Interpersonal Relationship, ES=Efficiency of the service and Ɛ = error.

Table 1: Estimated values of the Parameters in the fitted Regression Model Parameter Estimate Table

Variable	Estimated coefficient	Significant value
Threshold		
Trust = 3	- 8.496	0.000
Trust = 4	-7.653	0.000
Trust = 5	- 6.245	0.000
Trust = 6	- 5.708	0.000
Trust = 7	- 3.417	0.008
Trust = 8	0.024	0.985
Location		
Relationship continuity	0.070	0.548
Reputation 2	- 1.979	0.167
Reputation 3	0[a]	-
Conflicts solving 0	2.196	0.007 ***
Conflicts solving 1	0[a]	-
Confrontations	- 0.378	0.051
Telephone frequency	0.098	0.001 ***
Experience	- 0.212	0.078
Interpersonal relationship 0	- 2.832	0.013 ***
Interpersonal relationship1	0[a]	-
Efficiency of services 2	- 3.606	0.012 ***
Efficiency of services 3	0[a]	

Source: SPSS output * Significant at 5% significant level

Table 1 contains the estimated coefficients for the model. The estimates labeled thresholds are the α_j's, the intercept equivalent terms. The estimates labeled locations are the coefficients for the predictor variables.According to table 4.5, Reputation (Good), Taking immediate solutions for conflicts (Yes), Having interpersonal relationship (Yes) and Efficiency of the services (Efficient) were dropped to avoid singularity problems in the respond. All these variables were measured relative to the dropped categories. Estimated coefficients are tested by using standard errors and p-values

Conclusion

The results of the study revealed that frequency of telephone calls, taking immediate actions to solve problems, interpersonal relationship and efficiency of service providing were significant factors on the buyers' level of trust on tea brokers at 5% significant level. Brokers should consider much on significant factors, to increase the buyers' trust level towards them by doing adjustments according to the identified factors.Experience of buyer in the tea industry (number of years in the industry as a buyer) is not affect to their trust on tea brokers. Therefore brokers should consider on all buyers without any differences according their working period in the tea industry. Sometimes though a broker is given more respect and consideration to experienced buyer, some new buyers will trust the broker than old buyer. And when having trust, it is not difficult to continue the business relationship with buyers.

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Development of Green Tea incorporated Ayurvedic toothpaste

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Introduction

The tea plant *Camellia sinensis* is native to South East Asia and consumed worldwide, although in greatly different amounts. It is generally accepted that, next to water, tea is the most consumed beverage in the world, with per capita consumption of $120mLd^{-1}$. Green tea contains polyphenolic compounds, which include flavanols, flavandiols, flavonoids, and phenolic acids and account for 30% of the dry weight of green tea leaves. Green tea contains compounds that appear to control inflammation and fight bacterial infection. This drink is also rich in antioxidants, which have many oral health properties as Cavity prevention, Gum health, Less tooth loss, Cancer control, Better breath (Lisa, 2011). But the oral health benefit of the green tea is less aware by the people (Narotzki *et al*, 2012). This study is aimed to develop green tea incorporated ayurvedic toothpaste by addition of five different herbs to enhance the natural flavor of the tooth paste while increasing the oral health benefits.

The main objective is to develop ayurvedic toothpaste incorporating green tea and evaluate it for selected quality parameters. Other objectives are to determine the appropriate green tea and herbal oil incorporation quantity, to evaluate taste of the toothpaste (strength, bitterness), liquor color, smell, freshness after washing and the overall acceptability as quality indicators.

Materials and Methods

The green tea ayurvedic toothpaste consists with chemical mixture, green tea extract and herbal oil. To prepare the toothpaste chemical mixture 325g of powdered Calcium Carbonate ($CaCO_3$), 5g of Carboxy Methyl Cellulose (CMC), 10g of Sodium Lauryl Sulfate (SLS) and 2g of Methyl Paraben were mixed well during 15 minutes. And 110 mL of distilled water, 70 mL of glycerol and 70 mL of sorbitol were mixed in a separate dish and poured in to the solid chemical mixture and mixed together until 30 minutes. It was stored in a sealed container.

To extract the herbal oil 110g of each powdered Clove, Welmee, Munamal and Aralu were ground by adding 100 mL of distilled water until herbal pulp was formed. And the pulp was boiled during 10 minutes at constant temperature while mixing with 500 mL Sesame oil until evaporated the total water amount. Green tea – water extraction was done using reflux extractor (ISO 1574:1980). To prepare the green tea ayurvedic toothpaste all the three ingredients (chemical mixture, green tea and herbal oil) were mixed together at 1% , 2% of green tea extract and herbal oil levels.

Sensory evaluation with 30 untrained panelists was carried out to select the best green tea, and herbal oil incorporation quantity for the formulated toothpaste. Five point hedonic scale was used to evaluate samples for taste (strength, bitterness), color of the paste, smell, freshness after washing and the overall acceptability. Data were statistically analyzed using Freidman test at 5% level of significance using MINITAB statistical software.

The pH value of the developed toothpaste was measured with electronic pH meter. Determination of Moisture and Volatile Matter, Foaming Volume and Stability of the toothpaste were done based on SLS 275:2006 specifications.

Determination of polyphenol content of the toothpaste was done according to the ISO 14502-1 specifications. Prepared green tea ayurvedic toothpaste and control were tested for well diffusion assay using experimental microorganism included *Strephylococcs aureus* and the mean zone inhibition was measured (Awadalla *et al*, 2011). A total plate count test was done to determine the microbial evaluation of the toothpaste. The prepared mouthwash was subjected to a storage study by observing color and the smell at two weeks intervals and the pH of the product also measured.

Results and Discussion

Analyzed statistical data of the sensory evaluation of first experiment revealed that, there was a significant difference ($p<0.05$) among five treatments in respect to the all the sensory attributes tested. According to the Figure 1, Second treatment combination (475) which consisted of 1% of green tea extract and 2% of herbal oil amounts were selected as the best treatment to develop the new product since each of the significantly different attribute bears the highest rank mean and median values except colour of the product.

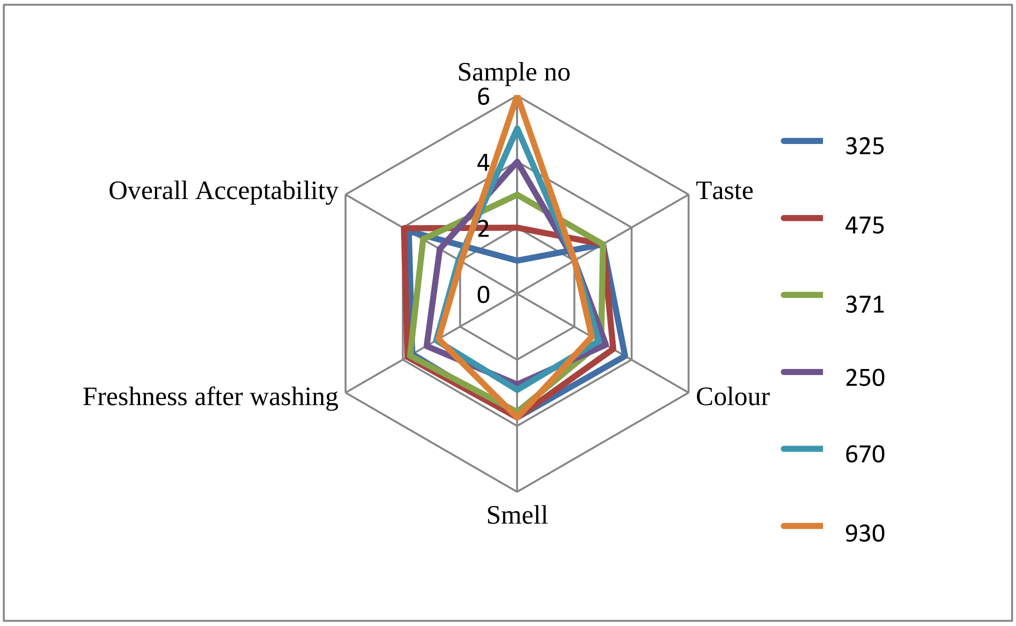

Figure 1: Sensory profiles of different treatments tested

The pH value of the toothpaste was 7.12. It was in the favorable pH range 5.8 – 10.5. As well as there was no any variations of the pH values during the storage. The toothpaste was consisted with 52% of moisture and volatile matter. It was in the favorable range 12 to55 percent by mass. Foaming volume of the toothpaste was 51 mL by fulfilling minimum SLS requirement

Toothpaste was having good stability at 0ºC to 45ºC temperature range and the total polyphenol content of the toothpaste was 23%. The fluoride concentration of the toothpaste was 4 ppm and it was having good effectiveness against the *Strphylococcus aureus* and free from coliform bacteria based on microbial evaluation (Figure 2), zone of inhibition and coliform test.

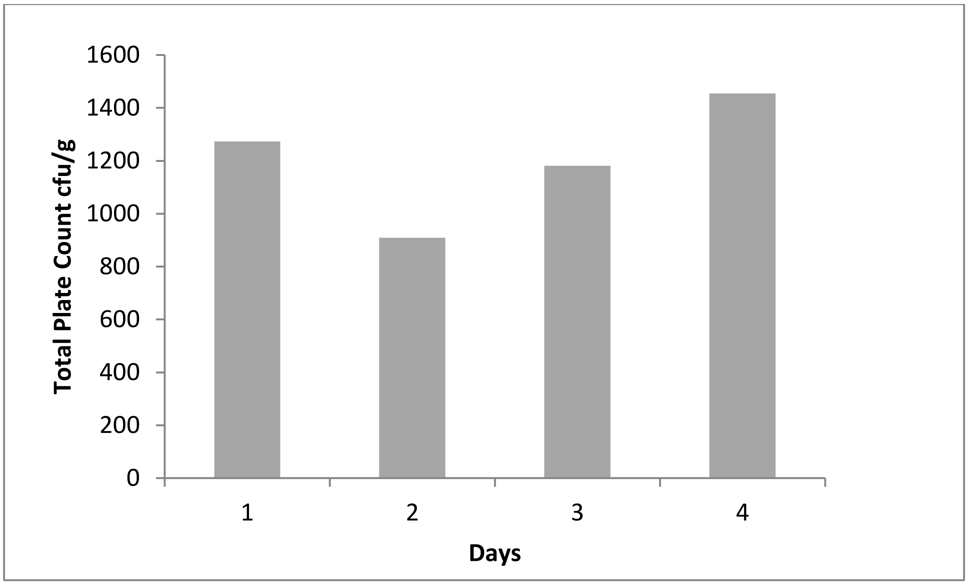

Figure 2: Variation of Total Plate Count with the Time

The total colony count was increased during 4 days period.The cost of production of 1g of toothpaste was Rs.1.80 based on cost for all chemical and non-chemical ingredients.

Conclusion

To develop good quality ayurvedic toothpaste 1% of green tea extract and 2% of herbal oil amount were selected. The new product contains an appropriate polyphenol content, foaming volume, stability, pH value by fulfilling SLS requirement. The new product can store in cool and dry place at 0^oC to 45^oC temperature range. Based on the microbial studies, ayurvedic toothpaste was having good effectiveness against *S.aureus* and coliform bacteria.

Acknowledgment

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Effect of Black Tea adulteration on quality parameters of Black Tea

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Introduction

Black tea is produced by withering, rolling, fermentation and drying from the tender shoots of varieties of the species *Camellia sinensis* (L.) (ISO 3720, 2011). Black tea adulteration is a particularly massive problem because of the universality of its consumption (Kariyawasam, 2014). Since black tea is a pure beverage material, it should be free from extraneous matter, added colouring matter and harmful substances (FSSAI, 2011). But sugar, ferrous sulphate and sodium bicarbonate are added majorly to black tea during manufacturing to improve colour of tea particles and weight of tea (Deshappriya, 2013; Kariyawasam 2014). The current study was carried out at Sri Lanka Tea Board to investigate the effect of major adulterants on quality parameters of black tea.

Materials and Methods

Black tea manufacturing was carried out in Uva medium black tea manufacturing factory following general requirements and steps (withering, rolling, fermentation and drying). 50% sugar, 10% sodium bicarbonate and 10% ferrous sulphate solutions in mass fraction were treated separately to first dhools as adulterants after rolling and kept it for fermentation. Those adulterated black tea samples and pure black tea samples were analysed for quality parameters such as, total polyphenol content, moisture content, total ash, water soluble ash, alkalinity of water soluble ash, water extract, total plate count, total liquor colour and brightness.

These quality parameters were analysed in accredited analytical laboratory at Sri Lanka Tea Board according to the ISO 14502-1: 2005 for total polyphenol content of black tea, ISO 1573: 1980 for loss in mass at 103 $^{\circ}$C (moisture content), ISO 1575: 1987 for total ash, ISO 1576: 1988 for water soluble ash and water insoluble ash, ISO 1578: 1975 for alkalinity of water soluble ash, ISO 1574: 1980 for water extract, SLS 516-1: 1991/ ISO 4833: 2003 for total plate count, spectrophotometric method described by Roberts, and Smith (1963) for determination of total colour and brightness of black tea. The data were statistically analyzed with ANOVA using Minitab statistical package. Mean comparisons with control level (pure black tea) and multiple mean comparison were performed by Dunnett simultaneous test and Tukey simultaneous test using General Linear model at 5 % significance level.

Results and Discussion

Externally added sugar, sodium bicarbonate and ferrous sulphate significantly ($p<0.05$) affected on total polyphenol content, total ash, water soluble ash, alkalinity of water soluble ash, water extract, total colour, brightness and total plate count except on moisture content.

According to the Figure 1, the highest total polyphenol content (14.38 %) was recorded by pure black tea while the lowest (8.81 %) was given by ferrous sulphate adulterated black tea. It was lower than the ISO 3720 limit (9 %) which may be due to formation of Fe-Polyphenol complex during fermentation stage. High concentration of ferrous result in localized formation of iron polyphenols complex in made tea (Venkatesan *et al*., 2006). The total polyphenol content in sodium bicarbonate and ferrous sulphate adulterated black tea samples were significantly lower ($p<0.05$) compared to pure black tea sample whereas mean difference of sugar adulterated black tea sample was not significant ($p>0.05$). Total ash, water soluble ash, water extract values recorded by all three adulterated black teas were within the ISO 3720 limits while alkalinity (3.26 %) of sodium bicarbonate adulterated black tea was beyond the ISO 3720 limit (1-3 %). The alkalinity of sodium bicarbonate adulterated black tea sample was significantly higher ($p<0.05$) than pure black tea. The alkalinity of sugar and ferrous sulphate adulterated black tea samples were significantly lower ($p<0.05$) than pure black tea.

The highest total colour (6.07 %) was observed in ferrous sulphate adulterated black tea while giving the lowest brightness (13.54 %) due to the lowest polyphenol content. Total polyphenol content is positively correlated with brightness which is responsible for tea liquor quality (Kottawa-Arachchi *et al.,* 2011). Total colour for sugar and ferrous sulphate adulterated black tea samples were significantly higher ($p<0.05$) compared to pure black tea while the total colour for sodium bicarbonate adulterated black tea sample was significantly lower ($p<0.05$) than pure black tea. Brightness values for all adulterated black tea samples were significantly lower ($p<0.05$) than pure black tea. TPP - total polyphenol content, MO - moisture content, TA - total ash, WSA - water soluble ash, ALK - alkalinity, WE - water extract, TC - total colour, BRI - brightness.

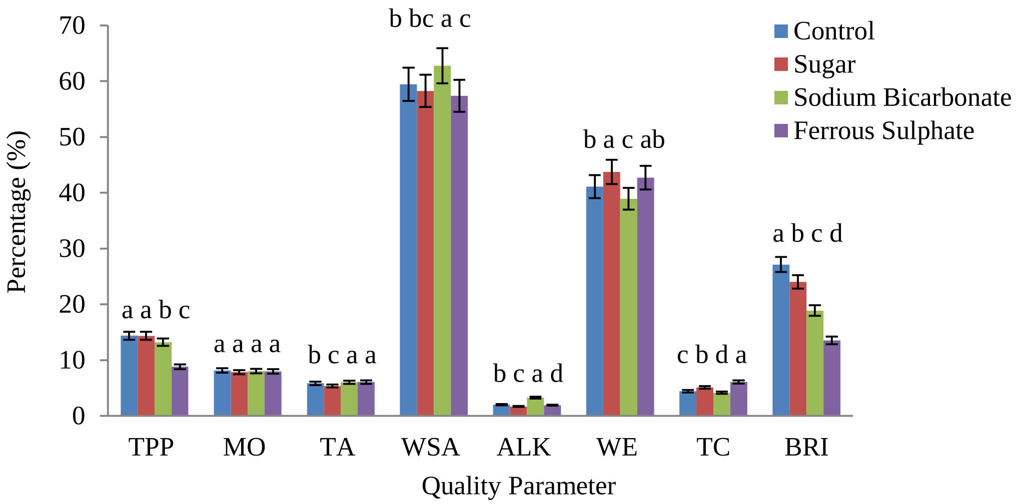

Figure 1: Effect of adulterant on ISO 3720 parameters, total colour and brightness of black tea

The variation of total plate count with respect to adulterated black tea samples at 78 % RH and 30 °C during storage are given in Figure 2. Sugar adulterated black tea exhibited the highest total plate count (1317 cfu/g). It may be due to, sugary outer layer of tea particles helps microorganisms to grow rapidly. However, it was within the SLS 516-1 limit (10000 cfu/g) for black tea. According to the present findings, addition of ferrous sulphate led to lower the total plate count (365 cfu/g) in black tea compared to pure black tea. Fe (II) acts synergistically to delay the growth of diverse bacteria, at environmentally relevant metal concentrations (Bird *et al*., 2013). Effect of interaction between adulterants and time was significant ($p<0.05$) on total plate count. Effect of adulterant factor and time factor individually were also significant ($p<0.05$). The total plate count value for sugar added black tea sample was significantly higher ($p<0.05$) compared to pure black tea sample while ferrous sulphate added sample was significantly lower ($p<0.05$) than pure black tea.

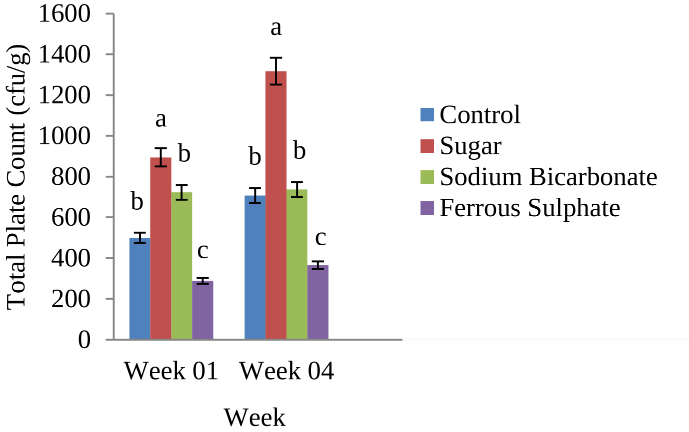

Figure 2: Effect of adulterant on total plate count of black tea over one month storage

Conclusion

The present study reveals that addition of sugar, sodium bicarbonate and ferrous sulphate to black tea significantly affect on total polyphenol content, total colour, brightness, total ash, water soluble ash, alkalinity of water soluble ash, water extract and total plate count of black tea except for moisture content. Usage of sodium bicarbonate as an adulterant for black tea lead to increase alkalinity percentage of water soluble ash beyond the limit which is given in ISO 3720 standard for black tea. Ferrous sulphate adulteration leads to drastically reduction of the total polyphenol content beyond the ISO 3720 requirement. Sugar adulteration results rapid growth of microbial colonies in black tea. Thus the study clearly highlights that adulteration of black tea by sugar, sodium bicarbonate and ferrous sulphate result poor quality black teas which have blackish appearance of tea particles with dull liquor colour and lower brightness.

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Effect of thermal time on shoot growth and development of low grown Tea [*Camellia sinensis* (L.) O. Kuntze] in Sri Lanka

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Introduction

Tea [*Camellia sinensis* (L.) O. Kuntze] is an important beverage crop in Sri Lanka and it is a sector where the country can take a lot of pride. The young, light green leaves, usually, the bud and the first two to three leaves are harvested for tea production. Study the shoot growth pattern of tea is an important element in tea physiology. It is difficult to predict leaf expansion and growth, based on calendar days, because leaf initiation and expansion are highly temperature dependent (Ritchie and Ne Smith, 1991). Because of the dependency on temperature, rate of shoot growth varies with elevation. Therefore, growing degree days based on actual temperature is a simple and accurate method to predict the occurrence of a certain developmental stage. Thus, thermal time can be used to predict the developmental stage of a leaf, extension of a tea shoot and Leaf Area (LA) expansion of shoot accurately.

This study was aimed to assess the variation in number of shoots at different developmental stages in the bush with thermal time, estimate shoot extension of a developing and harvestable tea shoot as a function of thermal time, estimate the Leaf Area (LA) of a developing and harvestable tea shoot as a function of thermal time and estimate the number of days taken to reach different leaf developmental stages of cultivar TRI 2025. This will provide an opportunity to estimate the shoot extension and Leaf Area (LA) expansion of harvestable tea shoot and it will help to adjust field management practices and to determine correct harvesting policies.

Materials and Methods

The field experiments were carried out at Field No 01, St. Joachim Estate, Tea Research Institute, Ratnapura, Sri Lanka (latitude : 6^{o} 40’ N; longitude : 80^{o} 25’ E) during mid of May to July 2014. Elevation of the study location is 29 m amsl and belongs to Agro ecological region of WL2. The soil group of the site belongs to Red Yellow Podzolic (Panabokke, 1996). The total rainfall was about 711 mm with a mean temperature of 28.5 ^{o}C during the experimental period. TRI 2025 was used as the planting material. Daily sunshine hours, rainfall, minimum maximum temperature was obtained from the meteorological station at St. Joachim Estate, Ratnapura. In addition, soil moisture was measured during the experimental period at weekly. Data analysis was done using MS-Excel and Minitab 16 software.

In the first experiment, field observations were made for TRI 2025 using 1m^2 sample size of plucking table with ten bushes at homogeneous location. The numbers of shoots at different shoot developmental stages in the bush (i.e. buds, bud with fish leaf, bud with one normal leaf, bud with two normal leaves, bud with three normal leaves and banjies) were counted at seven days interval. The accumulation of Thermal Time (TT) over the growing period was calculated using equations developed by Robertson *et al*., 2002. It was considered that T_{base} of 12.5 ^{o}C (Carr and Stephens, 1992), T_{Opt} 22 ^{o}C (Amarathunga *et al*., 1999) and T_{ce} 40 ^{o}C (Carr, 1972) for TRI 2025.

In the second experiment, with the appearance of each leaf, length of the shoot was measured at seven day intervals from randomly selected five axillary buds per bush that tagged immediately after plucking. The length of the new shoot was measured from the base of the shoot to the base of the bud. All measurements were taken until individual shoots reached their acceptable harvesting stage (bud with three normal leaves). Weather records obtained at experiment 01 were used in experiment 02.

In third experiment, Length (L) and width (W) of the individual leaves in a tea shoot (i.e. fish leaf, first, second, third normal leaf and bud) were measured at seven day intervals. Leaf length (L) was measured from lamina tip to the point of intersection of the lamina along the mid-rib, while leaf width (W) was measured from end to end between the widest lobes of the lamina perpendicular to the lamina mid-rib. The equation for TRI 2025 developed by (Jayasinghe *et al*., 2013) was used in estimating the Leaf Area (LA) at each day. In addition to that, record the number of days it was taken to unfolding of each appendage from the date of tagging and time it was taken to reach a acceptable harvesting stage having bud with a three leaf stage.

Results and Discussion

Experiment 01

Distribution of shoot generations in plucking table with cumulative thermal time from May to July 2014 is shown in figure 01.

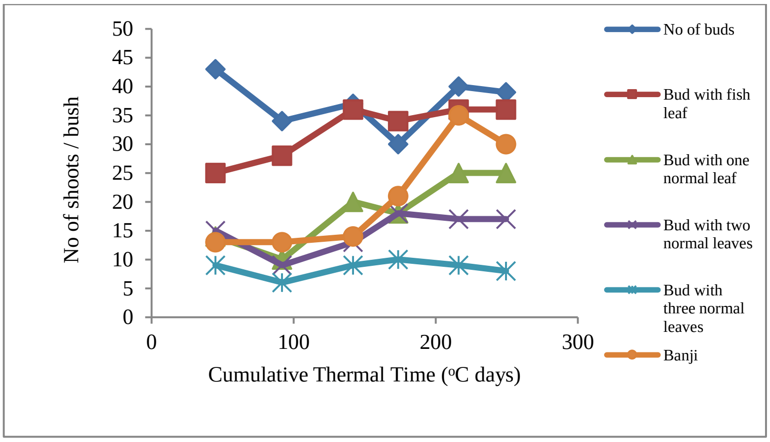

Figure 01: Distribution of shoot generations in plucking table with cumulative thermal time (ºC days) from May to July 2014.

According to the Pearson's correlation coefficient (r), there was a positive correlation between the number of shoots having bud with fish leaf (r = 0.912), bud with one normal leaf (r = 0.820), bud with two normal leaves (r = 0.688), bud with three normal leaves (r = 0.502), number of shoots having banji (r = 0.799) and total number of shoots (r = 0.848) per bush and the cumulative thermal time at 5 % probability level. According to the results average temperature, rainfall, daily sunshine hours and soil moisture were not significantly affect to the numbers of shoots at different developmental stages on the bush during the period at 5 % probability level.

Experiment 02

Mean shoot length of the tea shoot in relation to cumulative thermal time from May to July 2014 is shown in figure 02.

According to the Pearson's correlation coefficient (r), there was a positive correlation between the mean shoot length (r = 0.842) and the cumulative thermal time at 5 % probability level. According to the results, average temperature (P = 0.549), rainfall (P = 0.532), daily sunshine hours (P = 0.128) and soil moisture (P = 0.599) were not significantly affect to the length of the developing and harvestable tea shoot during the period at 5 % probability level.

According to the regression analysis, there was a very close relationship between the shoot length and the cumulative thermal time (R^2 = 0.956). Figure 02 showed that, growing bud needs to accumulate 249.56 ºC days to attain to the harvestable size having length of 112.34 mm.

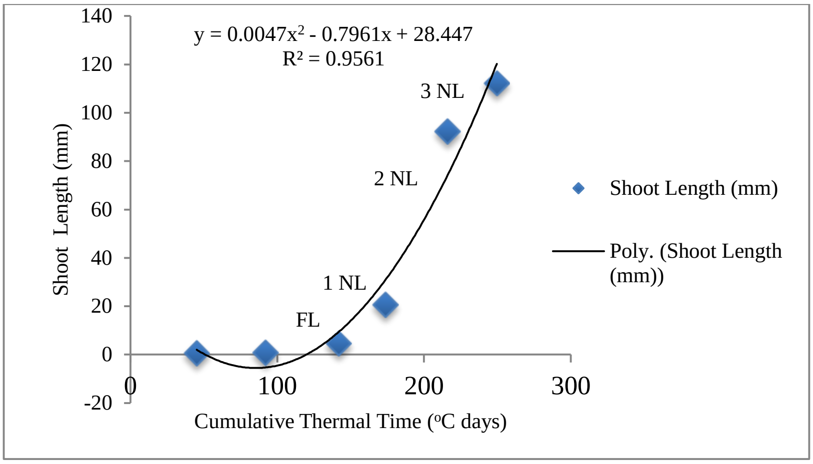

Figure 02: Mean shoot length (mm) of the tea shoot with cumulative thermal time from May to July 2014, note: FL – Fish Leaf 1NL – First Normal Leaf 2NL – Second Normal Leaf 3NL – Third Normal Leaf

Experiment 03

Total Leaf Area (LA) expansion of a tea shoot in relation to cumulative thermal time from May to July 2014 is shown in figure 03.

According to the Pearson's correlation coefficient (r), there was a positive correlation (r = 0.810) between the total leaf expansion of a harvestable tea shoot and the cumulative thermal time at 5% probability level. According to the results, average temperature (P = 0.463), rainfall (P = 0.553), daily sunshine hours (P = 0.074), soil moisture (P = 0.652) were not significantly affect to the Total Leaf Area (LA) expansion of the developing and harvestable tea shoot during the period at 5 % probability level.

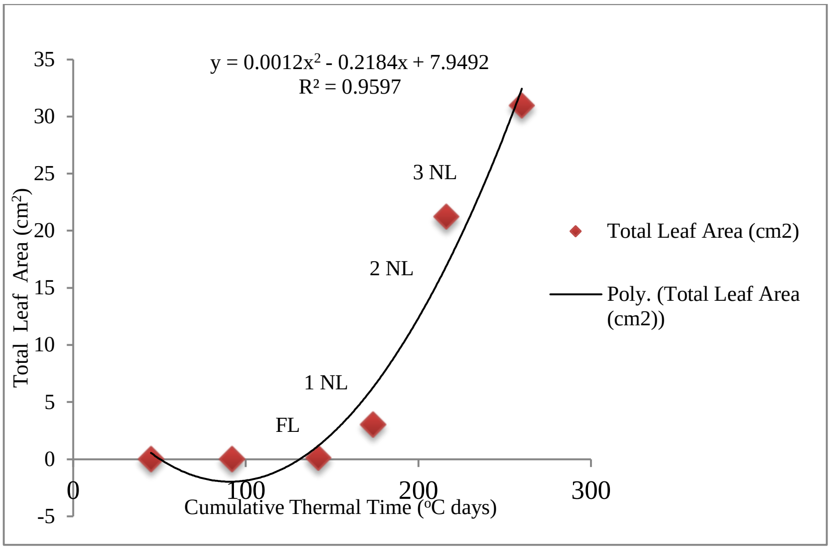

Figure 03: Total Leaf Area (LA) expansion of a tea shoot in relation to cumulative thermal time from May to July 2014, note: FL – Fish Leaf 1NL – First Normal Leaf 2NL – Second Normal Leaf 3NL – Third Normal Leaf

According to the regression analysis, there was a very close relationship between the Total Leaf Area expansion of developing and harvestable tea shoot with cumulative thermal time (R^2 = 0.959).

Conclusions

Leaf initiation, shoot extension and leaf expansion can be predicted using calendar days but it varies with the temperature and other environmental factors. Growing degree days based on actual temperature is a simple and accurate method to predict the occurrence of a certain developmental stage. After the bud break, growing tea bud required 24, 28, 32 and 35 days to produce fish leaf, the first normal leaf, second normal leaf and third normal leaf, respectively and bud break was occurred after 18 days from the date of tagging. In terms of degree days 153.82, 173.69, 197.28 and 216.17 °C days were required to initiate, fish leaf, the first, second and the third normal leaf respectively, after the removal of apical dominance by plucking. To attain a harvestable tea shoot (bud with three normal leaves) of cultivar TRI 2025 required with accumulation of 249.56 °C days (at mean temperature 28.5 °C and base temperature 12.5 °C. Length of the tea shoot having almost 112 mm in 41 days required to become pluckable size in low country region.

Acknowledgement

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Investigating the causes for poor control of *Crassocephalum crepidioides* (Thandam pillu) weed by Glyphosate in the Uva region

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Introduction

Weed management in tea field is great importance among other agronomic practices as weeds are the number one pest and they can lower the productivity of tea by 10 to 50 percent due to their competition for light, space, water and nutrients. Various weed management practices are used in tea cultivation such as manual, mechanical, cultural, chemical, and biological methods. Chemical weed control is the most convenient and effective methods among the various weed management techniques available. Unlike manual weeding, chemical weed control minimizes soil erosion and largely eliminates the loss of plant nutrients, which were carried away in the weeds removed from the field and less labour required. Other than normal classifications, weeds can be grouped as common weeds, hard-to-kill weeds and favorable herbs. Among the weeds Thandam pillu was considered as a common weed, but it is becoming a hard-to-kill weed. It was already become resistant to Paraquat herbicide and now there are complaints that it is difficult to control even by Glyphosate herbicide. Recent investigations under up country conditions have shown that such poor control is attributed to the dosage of Glyphosate applied and the age or growth phase of weeds, (Prematilake and Nawarathne, unpublished). Therefore, the objective of the present study was to elucidate the possible causes of poor control of Thandam pillu weed under Uva region.

Materials and methods

An experiment was carried out at the Uva Wellassa University during July-August 2014. C.crepidioides weed plants at five different growth phases such as 3-4, 5-6, 7-8, 9-10 and > 10 leaf phase, were collated from Ury Estate and they were planted randomly on raised beds, (30 plants per each growth phase) and left for 2 weeks to established. Two Glyphosate (36%) dosages (5 ml/L and 3 ml/L) were sprayed on plants by isolating the plant to prevent contaminations with other plants. An untreated Control was also maintained. Herbicide application was done as drenching application, by using hand sprayer during morning. The degree of chlorosis, wilting of leaves, scorching and drying of leaves and leaf fall occurred at 7, 14 and 21 days after application (DAA) of Glyphosate. Thandam pillu weed was observed and rated. Dead plant percentage, dry weight of viable plants and recovery of plants were recorded at 21 DAA.

Results and Discussion

Chlorosis was more prominent at 7 DAA and it occurred at significantly higher rate with Glyphosate at 5 ml/L than at 3 ml/L at 3-4 and 5-6 leaf growth phases. Leaf wilting was more prominent at 14 and 21 DAA and it occurred at significantly higher rate with Glyphosate at 5 ml/L at all five growth phases. Scorching and drying of leaves took place at the same rate with both Glyphosate at 5 ml/L and at 3 ml/L at 3-4, 5-6 and 9-10 leaf growth phases. However, symptoms were more severe with

Glyphosate at 5 ml/L than at 3 ml/L at 7-8 and >10 leaf phases. Leaf fall also occurred more severely with Glyphosate at 5 ml/L than at 3 ml/L at 7-8 leaf phase. Mean percentage of dead plants of C.crepidioides was significantly higher with Glyphosate at 5ml/L than that of 3ml/L at all growth phases. There was no death of the weed after phase 3 onwards with Glyphosate at 3ml/L and at phase 4 and 5 with Glyphosate at 5ml/L.

Table 01: Mean percentage of dead plants of C.crepidioides at different growth phases as affected by two dosages of Glyphosate

Treatments	Stage 1 (3-4 leaf)	Stage 2 (4-5 leaf)	Stage 3 (6-7 leaf)	Stage 4 (8-9 leaf)	Stage 5 (>10 leaf)
T1 (Gly: at 5 ml/L)	90 a	50 b	10 c	0	0
T2 (Gly: at 3 ml/L)	70 b	30 c	0	0	0
T3 (Control)	2 c	0	4 c	0	0

(Means followed by the same letter are not significantly different at $P<0.05$)

Mean dry weight per plant was not recorded at 3-4 and 5-6 leaf phases, but a lower weight was recorded at mature phases above 6-8 leaf phase. There was no significant different in weight between herbicide treatments and the Control. Poor response to Glyphosate at the maturity stages may be due to the hairiness of the leaves and stems and leaf angel (erect) act as barrier to absorb herbicide in to the plant.There was high recovery rate at latter phases in 3 ml/L Glyphosate treated plants than Glyphosate at 5 ml/L treated weed plants.

Table 02: Mean recovery of *C. crepidioides* at different phases with two Glyphosate dosages

Treatments	Stage 1 (3-4 leaf)	Stage 2 (4-5 leaf)	Stage 3 (6-7 leaf)	Stage 4 (8-9 leaf)	Stage 5 (>10 leaf)
T1 (Gly: at 5 ml/L)	0 c	0 c	0.2 b	0.3 b	0.3 b
T2 (Gly: at 3 ml/L)	0 c	0 c	0.2 b	0.2 b	0.5 a
T3 (Control)	0 c	0 c	0 c	0 c	0 c

(Means followed by the same letter are not significantly different at $P<0.05$)

Finally, *C.crepidioides* at early growth phases with 3-6 leaf is more susceptible to Glyphosate herbicides and with higher dosage it is more susceptible for Glyphosate.

Conclusions

The degree of control of C. crepidioides weed is dependent upon the dosage of Glyphosate. The higher the dosage the greater the controlling efficacy.The growth phase or maturity level of C.crepidioides also a factor that cause to tolerate the control of Thandam pillu weed by Glyphosate (36 %). The initial growth phase of C.crepidioides up to 6 leaf per plant phase is more susceptible for Glyphosate.

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Development of Tea incorporated Jackfruit *(Artocarpus heterophyllus Lam)* cordial

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Introduction

Since few decades tea has become one of the most famous and commonly consumed beverage which only second to the water in the world. There is evidence that the bio active compound like polyphenols, flavonoids, catechins, caffeine which comprise in tea are responsible for the human health (Puneet, 2013) by helping to reduce the risk of cardiovascular diseases and some forms of cancer, promoting oral health, reduce blood pressure, helping for weight control, improving antibacterial and antiviral activity etc. Jackfruit is an excellent source of phytonutrients including lingans, isoflavones and saponins which all have anti-cancer properties due to their capacity to protect the body from the effects of free-radicals, slowing the degeneration of cells that can lead to degenerative diseases. Jackfruit also provides small amounts of essential fatty acids with an ideal omega 3 to omega 6 ratio of roughly 1:2. We now know that the ratio at which we consume these essential fatty acids is just as important, if not more important than how much we consume of them (Baslingappa, 2012). The ripened jackfruits have appealing flavor, color, and a taste that can be used to prepare a delicious fruit drink enriched with vitamins. Therefore, this research was carried out to develop a tea incorporating jackfruit cordial which enrich with nutritional and stimulant effect with the endurable cost of production and maximizing the consumer satisfaction.

Methodology

There were two treatments conducted by changing tea type as green tea and black tea and amount of tea. Jackfruit to tea combination was evaluated and trial was done in order to find the best overall acceptability and finally three treatments were prepared and evaluated on sensory, chemical and microbiological basis. The sensory evaluation was done using 30 untrained panelists. In chemical analysis, proximate composition was determined for moisture content, crude fat, crude protein, ash and carbohydrate for content. pH value, brix value and microbiological analysis were done for *Escherichia coli*, Total Plate Count (TPC) and Yeast and mold in weekly for 1 month and analyzed by using Friedman nonparametric statistical method.

Table 1: Six recipes developed in preparation of tea incorporated jackfruit cordial

Ingredients	Sample Codes					
	443	521	352	289	450	365
Jack fruit pulp (g)	500	500	500	500	500	500
Water (ml)	500	500	500	500	500	500
Sugar (g)	450	450	450	450	450	450
Black Tea (g)	40	30	20			
Green Tea (g)				40	30	20

Citric Acid (CMS) (g)	5	5	5	5	5	5
Sodium Meta bi-sulfite (SMS) (mg)	610	610	610	610	610	610

Results and Discussion

According to the sensory evaluation, two best recipes were selected from green tea and black tea incorporated recipes. With 20 g of tea added cordial recipe has given a desirable sensory attributes in sensory evaluation.

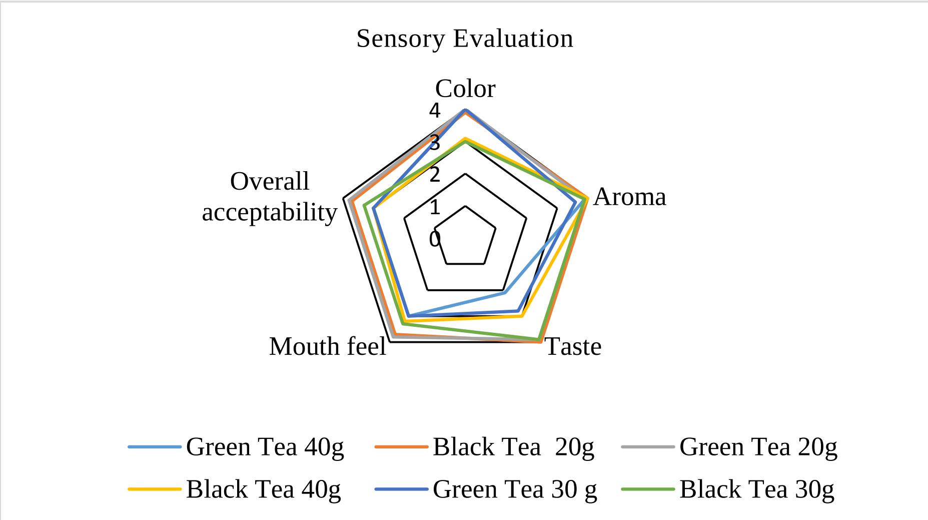

Figure 1: Web diagram for the sensory evaluation

There was a significant difference ($P<0.05$) among six samples regarding color, taste, mouth feel and overall acceptability.

Table 2: Proximate analysis for 30 ml sample of final products

Parameter	Black tea incorporated	Green tea incorporated
Moisture %	41.1	47.5
Ash %	0.5	0.3
Crude Protein %	1.0	0.7
Fat %	00	0.1
Carbohydrate %	57.4	51.4

As indicated by the Table 2, the highest moisture content and no fat was observed in green tea incorporated cordial followed black tea incorporated cordial. Highest crude protein and ash content was observed in black tea incorporated cordial.

The pH values of final products showed a slight elevation and it was between 4 to 5 pH levels. Total soluble solids (Brix) value for black tea incorporated cordial and green tea incorporated cordial were respectively 54° and 48°.

Total plate count in the samples complied with the requirement of Sri Lankan Standard (SLS). TPC value of both green tea and black tea added cordial has increased in increasing rate during first week. Then it has increased in decreasing rate with the time period. Yeast and mold and *Escherichia coli* were absent in both samples for four week time period.

Green tea incorporated cordial was contained 0.94 mg/mL polyphenol and black tea incorporated cordial was contained 0.72 mg/mL.

Conclusion

Tea incorporated jackfruit cordial can be produced from ripened jackfruit pulp and tea syrup, as a value added product having 54° brix for black tea incorporated cordial and 48° brix for green tea incorporated cordial. Black tea incorporated cordial consists with high nutritional value and zero fat. There is no significant undesirable changes in final products within storage period. Microbiological and chemical parameters in the recommended level.

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Factors affecting the level of effectiveness of dryers used in Sri Lankan tea manufacturing

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Introduction

Tea production is basically a drying process of freshly harvested green tea leaves, reducing its moisture content from about 75-83% down to 3%. In black tea manufacturing tea undergoes mainly withering, rolling, fermenting, drying, grading and packaging processing steps. Sri Lanka mainly produces tea by the Orthodox technology. Drying is the most expensive process in the manufacture of tea (http://www.biriz.biz/cay/TeaSector2002). The capital investment on dryers is also the highest among the different processing machines. There are three different types of tea dryers up to now namely ECP (Endless Chain Pressure), FBD (Fluidized Bed Dryer) and combination dryers. ECP dryer has been used in tea industry since 1907 and fluidized bed dryer was first developed for tea in Sri Lanka in 1974 (Temple S.J., 2000). Tea dryers have its defined output as rated output. But normally dryer machines give lower output (actual output) than rated output. There may be several reasons affecting for dryer output deviation from rated output. Ultimately this would lead to poor production and high cost of production to the tea factories.

Main objective is to find out the factors affecting for deviation of actual dryer output from rated dryer output in different types of tea dryers.

Materials and Methodology

Effectiveness of three types of tea dryers was taken as dependent variable. Effectiveness of tea dryers can be measured as the ratio between actual output and rated output. It will be finally taken as a percentage value.

As independent variables four factors have been selected as moisture content of withered leaves (wither percentage %), age of three types of dryers (Years), moisture of firewood used for drying (firewood moisture) and dhool percentage taken after roll breaking process (first, second and third dhool percentage).

The sampling frame was 37 tea dryers representing three manufacturing regions in Sri Lanka (Up country, Mid country and Low country). There were 17 ECP dryers, 15 FBD dryers and 5 combination dryers in the sample. The data were collected for recent three months time period and average values were taken finally. For the analysis descriptive, correlation and simple linear regression was used.

Results and Discussion

According to descriptive statistics mean effectiveness of ECP, FBD and combination dryers were 85.88%, 89.83%, 91.53% respectively.

Table 1: Descriptive statistics Results of Effectiveness of Tea Dryers

Dimension	**Dryer Type**	**Mean**	**Minimum**	**Maximum**
Effectiveness	ECP	85.88	72.73	93.33
	FBD	89.83	83.64	97.22
	Combination	91.53	83.33	96.15

Table 2: Pearson Correlation Results

Dryer Type	Factors	Correlation Coefficient	Status of Correlation
ECP Dryer	Wither Percentage	-0.957	Strong Negative
	Age of the Dryer	-0.992	Strong Negative
	Firewood Moisture	-0.967	Strong Negative
	Dhool Percentage	0.955	Strong Positive
FBD Dryer	Wither Percentage	-0.862	Strong Negative
	Age of the Dryer	-0.977	Strong Negative
	Firewood Moisture	-0.957	Strong Negative
	Dhool Percentage	0.912	Strong Positive
Combination Dryer	Wither Percentage	-0.946	Strong Negative
	Age of the Dryer	-0.969	Strong Negative
	Firewood Moisture	-0.971	Strong Negative
	Dhool Percentage	0.960	Strong Positive

Correlation results showed that wither percentage, Age of the dryer and Firewood moisture has strong negative relationship while dhool percentage has strong positive relationship for the level of effectiveness of three different types of dryers. The correlation results further support to run the regression.

Simple Linear Regression Model resulted following results.

Dryer Type	Factors	R-sq value	P-value
ECP Dryer	Wither Percentage	91.6%	0.000**
	Age of the Dryer	98.3%	0.000**
	Firewood Moisture	93.6%	0.000**
	Dhool Percentage	91.3%	0.000**
FBD Dryer	Wither Percentage	74.3%	0.000**
	Age of the Dryer	95.4%	0.000**
	Firewood Moisture	91.6%	0.000**
	Dhool Percentage	83.1%	0.000**
Combination Dryer	Wither Percentage	89.6%	0.015**
	Age of the Dryer	93.8%	0.007**
	Firewood Moisture	94.3%	0.006**
	Dhool Percentage	92.2%	0.009**
**significant at 0.05			

All the four factors has been affected for the level of effectiveness of three dryers because of simple linear regression model significant at 0.05.

Conclusion

Level of effectiveness of three different types of tea dryers were affected by wither percentage of tea leaves used for drying, age of the dryers, firewood moisture and dhool percentage. Effectiveness of dryers were decreased with increasing of wither percentage, age of the dryers and firewood moisture while increased with increasing dhool percentage. Further research could be done by increasing sample size to overall Sri Lanka and finding more factors which will affect for deviation of dryer output than rated output.

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Effect of Tea bag materials on physical and chemical quality parameters of Black Tea during storage

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Introduction

The tea (*Camellia sinensis*) produced in Sri Lanka is popular as "Ceylon tea" and has a higher demand as 'best quality tea' in the international trade. Packing tea into bags in many forms has become very popular because of convenience and it can be considered as an effective form of value addition. Though tea bags are used as packaging strategy in order to protect the quality parameters of tea during storage, while extending the shelf life, there are many quality claims against tea bag materials. The other bad news is that paper tea bags may be just as bad, or worse, than the plastic ones because many of them are treated with epichlorohydrin, a compound mainly used in the production of epoxy resins. The purpose of this research was to evaluate effect of different types of tea bag packaging materials on physical and chemical parameters of tea and selecting best tea bag packaging material.

Methodology

There are three types of tea bag materials as Paper, Soilon and Nylon that used to export tea in Sri Lanka, were used for this research. Those tea bags contained black tea with same manufacturing date, and also they were received from same tea exporting company. Each tea bag was consisting with Broken Orange Pekoe Fannings (BOPF) grade of black tea and tea bags were in same shape, size and same weight (2.5g) of tea. Each type of tea bag was packed in same size of sealed cardboard boxes and they were stored in normal room temperature. Each box was consisted with 25 tea bags.

Tea bags were stored for three months duration. Every experiment was conducted three times at same time intervals in each month of during storage period and data was collected in each month. Experiments were conducted using selected physical and chemical quality parameters of black tea. Moisture content, dry matter, brightness, total colour were measure as physical quality parameters and total polyphenols, caffeine, thearubigin, theaflavin and thearubigin to theaflavin ratio was measured as chemical quality parameters. Three replicates were carried out for each type of materials in each experiment. Every experiment was conducted according to ISO procedures recommended for black tea.

All data were expressed using descriptive statistics as means, standard deviations and coefficient of variations of triplicate measurements and analysed by using Minitab 16 software. Significant effects were tested by conducting two sample t-tests for each packaging materials by comparing with the initial data set of each material separately. Values of $P<0.05$ were considered as significantly different ($\alpha=0.05$).

Results and Discussion

Table 1: Means, SD, SE, and Coef.Var. of Chemical Components of Tea Samples with Different Tea Bag Materials

Quality Parameter	Material	Mean	St. Dev.	SE Mean	Coef. Var.
Moisture	1	7.917	0.483	0.837	10.58
	2	7.760	0.556	7.24	7.24
	3	7.627	0.732	9.60	9.60
Dry matter	1	89.767	0.527	0.914	1.02
	2	90.210	0.320	0.555	0.62
	3	90.000	0.381	0.660	0.73
Theaflavin	1	0.328	0.028	0.048	14.72
	2	0.375	0.009	0.016	4.38
	3	0.356	0.018	0.031	8.61
Thearubigin	1	16.320	0.769	1.333	8.17
	2	16.607	0.299	1.517	3.11
	3	17.063	0.407	0.704	4.13
TF/TR	1	0.0197	0.0029	0.0051	26.09
	2	0.0223	0.0009	0.0015	6.84
	3	0.0203	0.0007	0.0012	5.68
Brightness	1	16.68	1.10	1.91	11.47
	2	17.52	1.26	2.18	12.41
	3	14.858	0.368	0.638	4.30
Total Colour	1	5.503	0.085	0.147	2.67
	2	5.203	0.379	0.656	12.61
	3	5.466	0.404	0.700	12.80

Total Polyphenol	1 2 3	12.262 13.239 12.813	0.051 0.039 0.087	0.087 0.067 0.151	0.71 0.51 1.18
Caffeine	1 2 3	1.977 2.007 2.047	0.059 0.022 0.057	0.1027 0.0371 0.0982	5.19 1.85 4.80

Material 1-Paper Material 2-Soilon Material 3-Nylon

The highest mean value of moisture content of black tea contained in paper tea bags were 7.917 %, ranged from 06.97 - 8.56 % with soilon and nylon tea bags which are having the lower change of moisture 7.04 - 8.09 % and 6.79 - 8.15 % respectively and coefficient of variation 10.58 %. Soilon tea bags having lowest moisture change range from 6.79 – 8.15 % and coefficient of variation 7.24 %. High moisture content aids microbial activities, oxidation – reduction processes and fungal growth. The variation in the moisture may be attributed to the degree of drying type and nature of tea involved (Kumar *et al*., 2005).According to this study it is because of the different textures of these three materials affect for the absorption of the moisture during the storage. Another important factor is use of packaging material to maintain a constant moisture level during storage of commercial tea samples, so moisture content in commercial tea is an essential parameter of quality (Yao *et al*., 2006).

The results of the dry matter analysis are as shown in Table 1, lowest changes of dry matter content was resulted from soilon tea bags which having lowest coefficient of variation 0.62 %.

The theaflavin (TF) content analysis results are shown in Table 1, which follows the order Soilon > Nylon> Paper with a means of 0.375 %, ranging from 0.394 -0.363 % and coefficient of variation 4.38 %.

The results of TF/TR content in Table 1, showed that soilon tea bag had the least change of value of TF/TR ratio of mean 0.0223, ranged from 0.024 - 0.021 with lowest mean 0.0197 of the paper tea bags ranging from 0.024 - 0.014 while nylon tea bag having the mean distribution value of 0.0203 TF/TR content ranged from 0.024 - 0.019 with coefficient of variation 5.68 %, which is low when compared with the paper and soilon, 26.09 % and 6.84% respectively.

Least change of brightness during storage was obtained from nylon tea bags having lowest coefficient of variation 4.3%.

According to Table 1, lowest change of the total colour was obtained from nylon tea bags, mean 5.503, ranged from 5.53 – 5.643 having coefficient of variation 2.67 % compared to soilon and nylon tea bags means 5.203 and 5.466 are ranged from 5.36 - 4.483 and 5.023 – 6.273 with coefficient of variations 12.61 % and 12.80 %.The TR content gives the tea liquor its depth of colour and more TR content means very strong and coloured liquor with less briskness as caffeine along with TF contribute towards briskness. This method also includes the measurement of total colour, which is the combined contribution of colour from TF and TR present in the tea liquor (Borah and Bhuyan).

The results of the Total polyphenol analysis as shown in Table 1 with mean distribution of paper tea bags 12.34 %, ranged from 12.34 – 12.167 % and coefficient of variation 0.7 %, soilon and nylon tea bags having lower total polyphenol changes, ranged from 13.313 – 13.181% and 12.940 – 12.646 % with their means and coefficient of variances 13.239 %, 12.813 % and 0.5 % and 1.18 % respectively and least changes of total polyphenol was obtained from soilon tea bags.

The results of the caffeine analysis as shown in Table 1 with mean distribution of paper tea bags 1.977 %, ranged from 2.053 – 1.86 % and coefficient of variation 5.19 %, soilon and nylon tea bags having lower caffeine changes, ranged from 2.046 – 1.973 % and 2.133 – 1.940 % with their means and coefficient of variances 2.007 %, 2.047 % and 1.85 % and 4.80 % respectively and least changes of caffeine were obtained from soilon tea bags.

Table 2: Significant Effects of the Tea Bag Materials

Material	P Values									
	Time	**MC**	**DM**	**TF**	**TR**	**TF/TR**	**TC**	**Br.**	**TPP**	**Caff.**
Paper	2	0.049	0.000	0.448	0.305	0.212	0.971	0.665	0.139	0.020
Paper	3	0.017	0.041	0.117	0.019	0.025	0.431	0.499	0.023	0.000
Soilon	2	0.017	0.088	0.716	0.421	0.571	0.719	0.603	0.000	0.048
Soilon	3	0.007	0.080	0.633	0.114	0.377	0.813	0.307	0.003	0.015
Nylon	2	0.077	0.190	0.335	0.181	0.248	0.211	0.874	0.073	0.035
Nylon	3	0.050	0.161	0.118	0.048	0.076	0.571	0.097	0.004	0.002

2- 60 days (2nd month) **3**-60 days (3rd month)

According to two sample t-test, effects are significant ($P<0.05$) for the quality parameters such as moisture content, dry matter content, thearubigin, total polyphenol and caffeine in paper tea bags. Nylon tea bags showed significant effects for the thearubigin, total polyphenol and caffeine. Soilon tea bags showed significant effects for the moisture, total polyphenol and caffeine.

Highest numbers of significant effects for the quality parameters are detected from paper tea bags and minimum numbers of significant effects were detected from soilon tea bags.Descriptive analysis showed highest changes of quality parameters in paper bags and least changes of quality parameters in soilon tea bags.

According to descriptive analysis, t-test effects of changes of quality parameters were vary as Paper> Nylon> Soilon respectively.

Conclusion

The effects of packaging materials on each quality parameters are varied with the type of material. These variations are mainly due to nature and permeability of the material. Permeable materials allow moisture absorption with time if the moisture levels of the storage environment are not properly controlled. Moisture absorption is high in nylon and paper materials compared to soilon. Changes in Quality parameters of paper and nylon materials are comparatively higher than soilon. Compared to nylon and paper materials, soilon showed minimum significant changes of the quality parameters with minimum significant effects ($P<0.05$). According to descriptive and t-tests, can conclude 'Soilon' is the 'best' material for tea bags for these three months studying period.

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Development of a biscuit enriched with Tea polyphenols

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Introduction

Tea is receiving increased interest from food scientists due to its purported antioxidant properties and health benefits.Polyphenols in tea are believed as excellent chemical compounds. Several clinical studies have proved polyphenols to be active in disease prevention in several ways. Polyphenols have also been recently recognized as functionally active molecules, possessing antioxidant, anticancer, anti-mutagenic properties, as well as exerting protective effects against cardiovascular and other diseases.

Methodology

The current study was carried out at Eswaran Brothers Export (Pvt) Ltd, 104/11 GrandpassRoad, Colombo 14. Laboratory analysis was done at UvaWellassa University laboratories. Indore to find better extraction method for tea polyphenol, preliminary study was conducted by using ethanol and water. Extraction efficiencies of water and ethanol were tested in different time and temperature combination. The total polyphenol content in the tea extract was determined by measuring the color development with Folin-Ciocalteu phenol reagent in alkaline medium (ISO 14502-1), at absorbance of 765 nm using UV-VIS spectrophotometer. Gallic acid was used as a standard and the total polyphenol were expressed as mg / g Gallic acid equivalents (GAE). For this purpose, the calibration curve of Gallic acid was drawn. Through preliminary study of the polyphenol extraction, as a polyphenol source 40 g BOPF black tea concentered extracts were used for final product development. Three kind of final products were developed such as without extract, with water extract and ethanol extract. Organoleptic properties of the biscuits were evaluated using sensory analysis. Total polyphenol content of the final consumer accepted product also test with Folin-Ciocalteu phenol reagent in alkaline medium method.

Results and Discussion

Through preliminary study high polyphenol content was obtained water at $80^{o}C$ with 30 min extraction and 40 % ethanol solution at $40^{o}C$ with 2 hr. extraction.

Table 1: Detail of total polyphenol content in water and ethanol extracts

Solvent at $40^{o}C$	Solvent type	Time (hr.)	Yield mg GAE/g	Solvent	Temperature (^{o}C)	Time (min)	Yield mg GAE/g
Ethanol	100 %	4	507.38 ± 1.33	Water	100	60	84.71 ± 7.96
	100 %	2	618.98 ± 0.48		100	30	234.56 ± 20. 21

	80 %	4	606.59 ± 1.26		80	60	275.78 ± 6.16
	80 %	2	529.13 ± 6.34		80	30	320.50 ± 7.29
	40 %	4	396.08 ± 1.06		60	60	274.73 ± 14.56
	40 %	2	671.28 ± 2.18		60	30	241.65 ± 0.98

Through the sensory analysis higher acceptance for overall acceptability ($p<0.05$) was observed for ethanol extract incorporated biscuit.

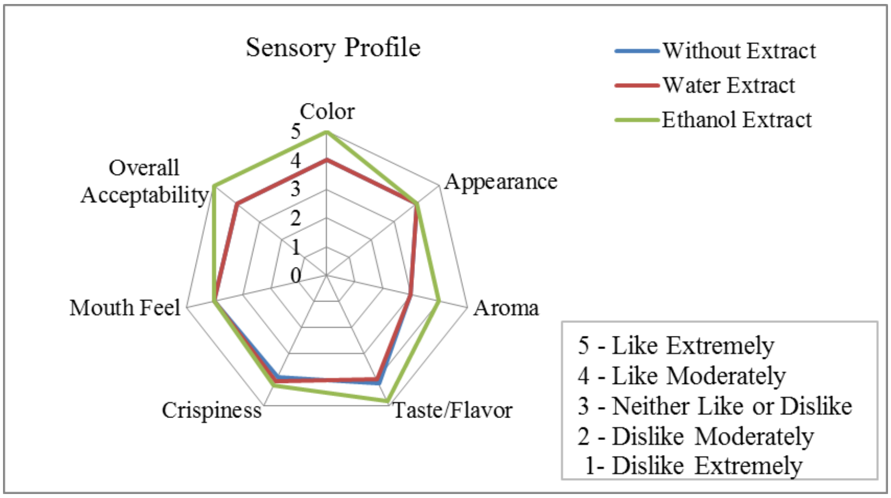

Figure 1: Overall sensory profile for developed product

On the basis of the United States Department of Agriculture “Serving Sizes” (for tea 240 ml), Balentine (2001) showed that black tea having 120 – 300 mg flavonoids / serving. (USAD Serving Sizes Hand Book).Total polyphenol content in consumer accepted biscuit ranged between 551.25 – 521.07 mg/10g (one biscuit), that mean one biscuit is equal to two cup of tea according to USAD Serving Sizes. If one person consume one cup of tea with developed biscuits that will give equal benefits (Tea Polyphenol) of consuming three cups of tea.

Polyphenols rich biscuit

Plate 1: Cup of tea with made biscuit

Conclusion

The results from this study show that variations in the polyphenol content of various extracts depending on type of solvent used and that aqueous solvents were more efficient in extracting total polyphenol, compared to their corresponding absolute ones and using water.

Present study indicated that ethanol extracts were accepted by consumers as a polyphenol rich source in food product constituents, and might be an interest of wider usage as food components.

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Development of Black Tea incorporated tomato sauce

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Introduction

Tea has a lot of health beneficial components and also considered an energy active booster. Current trend is moving to the health benefits concepts and green production. Under this condition, there is a huge demand for black tea sauce like products. There is a high demand for Sri Lankan black tea in Global market due to some specific characteristics. But, still we are failing on tea value addition. Therefore, improving value addition practices and new product development are more essential to Sri Lanka to survive in the Global market.

Recently, research has focused on green tea. Green tea is loaded with the compound epigallocatechin gallate (EGCg), a powerful anti-oxidant. Since the fermentation process used to make black tea converts EGCg into other compounds, researchers assumed black tea had less health benefits than green tea. However, recent studies indicate the compounds contained in black tea which are theaflavins and thearubigens, do more than contribute to its dark color and distinctive flavor. They also provide health benefits originally attributed solely to green tea (Herath, H.M.U.N., and De Silva, D., (2006).

Objectives

The main objective in the present study was to black tea incorporated tomato sauce while the specific objectives were to determine appropriate amount of ingredients to be added to the product and to extend shelf life, in order to obtain the desired product quality.

Method

Small pieces of tomatoes and green chilies were mixed using a grinder and salt, chili, black tea brew, honey, garlic and tamarind extraction were added into the mixture until it becomes a cream. The cream was heated until it becomes tick. Then filled into the sterilized glass bottles by using hot filling method. All microbial analysis and proximate analysis were conducted according to the SLSI standard (260: 2008). Statistical analysis was undertaken according to the Friedman test under 5% significance level, by using MINITAB – 16 software package and Microsoft – Excel package.

Results and Discussions

Table 1 given the Physico-chemical properties and proximate analysis of black tea incorporated tomato sauce. According to proximate analysis, moisture content was 14 % and protein content was 0.5 %. Total soluble solid content of the product was 38. pH of the product was 4.42 and tritratable acidity was 3.69 %. Total poly phenol content was 350 mg GAE/g. By doing sensory evaluation from Friedman test from Minitab 16 software the product contained the best characters of sauce.

Table 1. Physico-chemical properties and Proximate Analysis of Black Tea Incorporated Tomato Sauce

Constituents	**Amounts**	**Method of Test**
Total Soluble solid Content (brix value)	38	SLS 1332
Total Acidity	3.69 %	SLS 347
pH Value	4.42	-
Total Poly Phenol Content	350 mg GAE/g	Gallic Acid
Moisture Content	14 %	SLS 348
Protein Content	0.5 %	SLS 348

According to the microbial analysis there were not yeast, moulds and *Escherichia coli* growth in the product. Total plate count was increased during 1 month period.

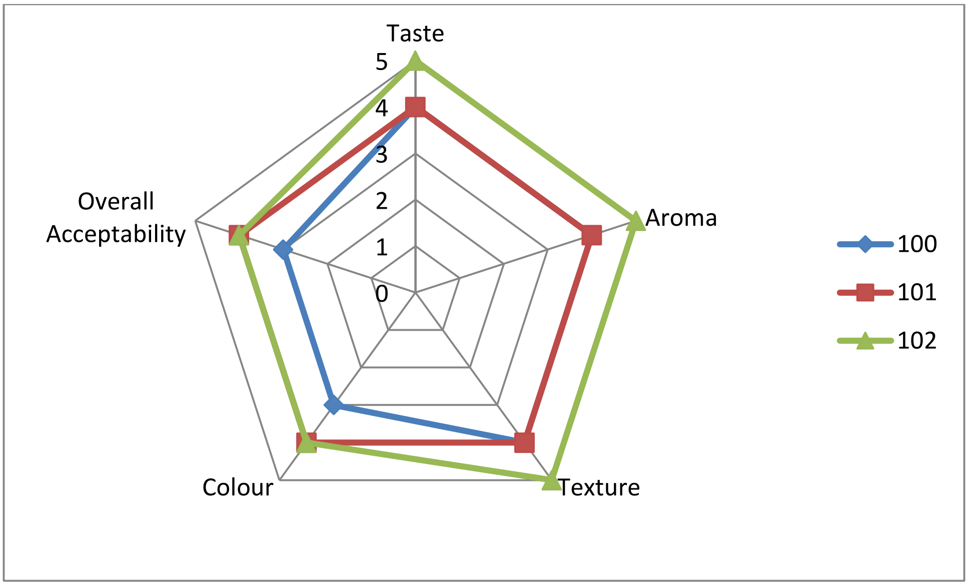

Figure 1. Web diagram for treatments 100, 101, 102 in sensory evaluation

Figure 1 shows that Taste, Aroma, Texture, Colour and overall Acceptability is higher in Treatment 102 than the other treatments.

Conclusion and Suggestions

As a new value added product if it will reach to customers, it may contribute to more Sri Lankan exports as well. Attraction from the child to the adult one to increase food appetite, low cost of production, low purchasing cost and high market demand are the key benefits of the product. By doing sensory evaluation from Friedman test from Minitab 16 software the product was include the best characters of sauce.

Treatment 102 has been selected as best products through sensory evaluation, proximate analysis and shelf life analysis. With reference to the microbial analysis, it can be concluded that the product have more than two months of shelf life.

According to the statistical analysis, nutritional analysis and microbial analysis the product remains under acceptable level of human consumption.

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Development of Green Tea incorporated instant herbal porridge mixture

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Introduction

As the second largest tea exporter in the world, the greater portion of tea is exported as bulk tea. Average price of bulk tea is lower than that of value added products (Ganewatta et al., 2005). There are several types of teas which are producing with different processing methods such as, Black tea, Green tea, Oolong tea and White tea. Among them, green tea is considered as the healthiest beverage in the world. It is loaded with antioxidants and nutrients have powerful effects on the body. (Gunnars, 2014). Because of the bitter taste of green tea, most of the consumers do not prefer to consume green tea alone. Herbal porridge which is considered indigenous to Sri Lanka, comprises with therapeutic values and nutritious. In Ayurvedic medicine Osbekicaoctandera (heenbovitiya), Murrayakoenigi (curry leaves) are highly recommended for the preparation of Herbal Porridge for Diabetes& heart patients in traditional ayurvedic medicine. O. octandra is a very valuable and widely utilized plant species in indigenous Ayurvedic medicine in Sri Lanka (Peiris et al., 2006).A study published in the (Journal of Plant food for Nutrition), found that curry leaves have a great impact on the blood sugar levels of diabetics (Sampath, 2014). It can be medicinally and economically more valuable to develop green tea incorporated instant herbal porridge mixture by using natural resources. The objectives of this research were:

- Develop a green tea incorporated instant herbal porridge mixture
- Find out the best ratio of dehydrated green leaf powder and green tea powder for herbal porridge mixture
- Determine the Shelf life of the developed product

Materials and Methods

Heenbovitiya (*Osbeckiaoctandra*) leaves and curry leaves (*Murrayakoenigi*) were steam blanched for two minutes separately and few minutes were allowed to drain excess water. Then leaves were oven dried at 60°C. Finally, well dried leaves were grinded and sieved well to obtain fine leaf powder for instant herbal porridge mixture. For the preparation of red rice for the instant herbal porridge mixture, cleaned red rice was presoaked for 4 hours and oven dried at 80°C. Cleaned soya beans were boiled for 25 minutes and oven dried at 80°C. Well dried soya beans were grinded to obtain fine powder for the porridge mixture. All the prepared ingredients were blended with three different levels of green tea powder (2.6, 3.6, 4.6g per cup) according to an Ayurvedic formula; the formula to prepare 25 cups of *Kolakanda* was rice 500g, fresh leaves 275g, soya bean 10g, raw garlic 10g, raw ginger 25g, salt 15g and water 5l (Gamlath et al., 2002).
The developed instant herbal porridge mixtures were evaluated for color, taste, aroma, texture and overall acceptability using 30 untrained panelists. The responses were recorded according to 5 point hedonic scale (5- extremely like to 1- extremely dislike). The sensory attributes were analyzed by Friedman test in MINITAB 14 statistical package and samples were compared by using 5% significant level.
Proximate analysis was carried out to determine the nutrient content of the selected best product through sensory evaluation. Total polyphenol content was determined according to the method based on ISO 14502 -1.
Detection of total plate count and yeast and mould were done during six weeks storage period. A sample of 31.4g of developed product was reconstituted for 5 minutes with 200ml of distilled water and 1ml of reconstituted sample was mixed with 9 ml of 0.1% peptone water in to test tube. After

completing appropriate dilution (10^{-2}) 1ml of the sample was introduce in to plates and it was allowed to be incubated at 25°C for two days. To determine the yeast and mould count potato dextrose agar (PDA) medium was used and to determine the total plate count plate count agar medium was used.

Results and Discussion

Table: 1 Results of Sensory Evaluation

Sensory attributes	**Treatments**			
	Treatment 1	**Treatment 2**	**Treatment 3**	**P- value**
Color	4.833	3.500	4.167	0.000
Taste	4.833	4.167	2.167	0.000
Aroma	4.667	4.000	3.333	0.000
Texture	4.333	4.167	4.000	0.103
Overall acceptability	5.000	4.000	3.000	0.000

*All the data are given as estimated median values
Given from p-value > 0.05 significant difference

- 3.6g of green tea powder mixed sample (treatment number 2) was selected as the best treatment.

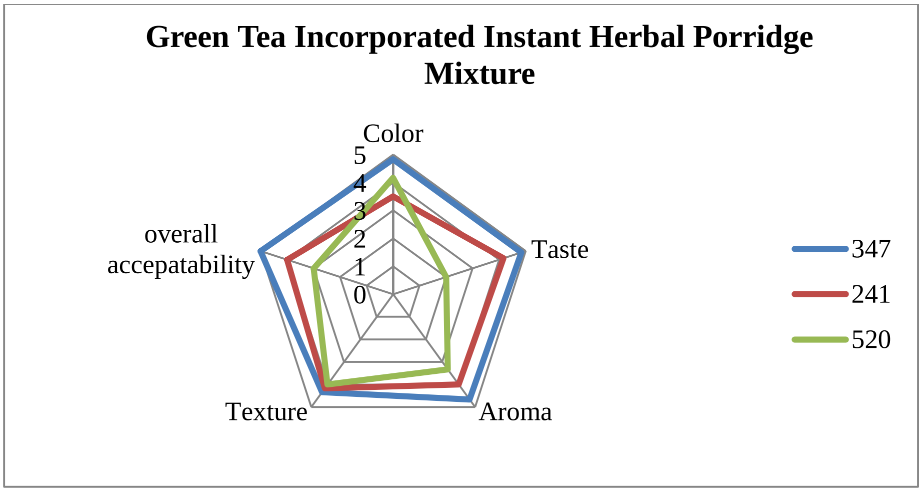

Figure 1: Results of Sensory Evaluation

Results of Proximate analysis were included in the table:2 is given below:

Table 2: Results of Proximate Analysis

Mositure	Protein	Crude Fat	Crude Fiber	Ash	Total Polyphenol
5.1%	2.1%	10%	0.6%	0.4%	573mg

Figure: 2 shows that the total plate and yeast and mould count of the product With the increasing time period of the storage. Total plate count were increased slightly but there were no colonies obtained for yeast and mould throughout the six weeks storage period.

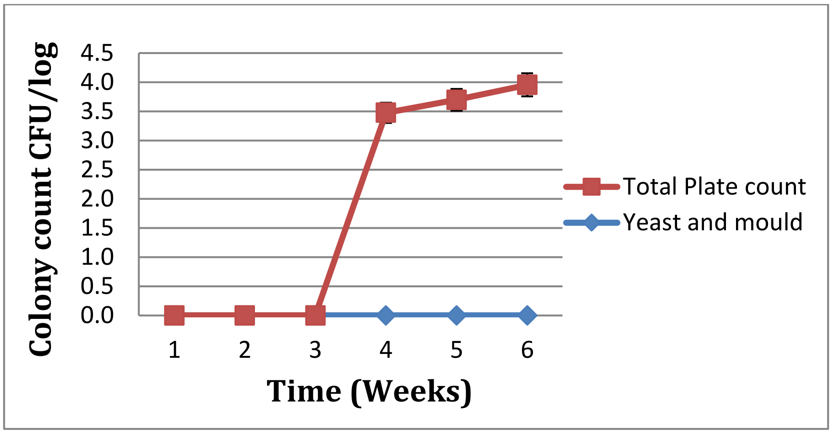

Figure 2: Microbial count of the Product

Conclusion

It can be concluded that, properly processed (according to above given procedures) green leaves, red rice and soya bean mixture has the ability to prepare porridge for consumption within 5 minutes. 3.6g from *heenbovitiya* power, 3.6g from curry leaf powder and 3.6g from green tea powder are the best green leaf powder ratio for the porridge mixture.Also product is stable under room temperature for more than one month under proper storageconditions(sealed Aluminum foil pouch under room temperature) with the moisture content of 5.1%).

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Effect of dolomite application on available phosphorus status in Tea soils

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Introduction

Tea (*Camellia sinensis* L.) is an important economic crop grown on highly weathered Oxisols and Ultisols in Sri Lanka. Phosphorus (P) is one of the most important macro nutrient that influencing growth, yield and quality of tea **(**Zoysa, 1997). Phosphorus deficiency is a concern, and a problem, in most tea soils. Research shows that over 70% of tea soils are P deficient (Lin *et al*., 1991). The availability declines rapidly as the soil pH falls below 5.5 or rises above 7. Therefore, measuring the soil pH helps the tea grower to adjust soil chemical condition suitable for nutrient uptake and plant growth (Zoysa, 2008). Dolomite is recommended for amelioration of acidity in tea soils. Present investigation was carried out to identify the effect of application of Dolomite on soil available phosphorus status in Tea Growing Soils.

Methodology

Site Description: This field experiment was carried out at field No 17, Midland's Lower Division, Ratota. Midlands is an estate(s) and is located in Central Province Matale District of Sri Lanka. Long term experiment was initiated in 2009. The experiment was carried out by using tea cultivar TRI 2023.

Experimental Design: Field experiment was laid out in Randomized Complete Block Design consisting of five treatments in different rate of Dolomite (tons/ha/pruning cycle) namely T1 (Absolutely control), T2 (1), T3 (2), T4 (3), T5 (4). Each treatment replicated thrice.

Soil sampling and Analysis: Soil samples of two depths 0-15 cm and 15-30 cm were collected from the randomly selected places in each plot as a bulk and sub sample was taken from the bulk after the mixing. pH of soil suspension was determined by using pH meter(ORION 510A model, USA) with Ag/AgCl combined electrode. Soil available phosphorou**s** was extracted by Borax solution (pH 1.5) and phosphoru**s** was determined by vanadomolybdate blue method (Beater,1949).

Statistical Analysis
The data generated from the study was subjected to Analysis of Variance (ANOVA) and treatment means were compared least significance difference at probability $p < 0.05$ using SAS statistical package version 9.1(SAS Institute, 1999).
Result and Discussion

Effect of application of different rate of Dolomite on soil pH

The effect of different rate of dolomite on pH in soils of 0-15 cm and 15-30 cm depths are presented in Table 1.Increasing trend in pH was observed with increasing dolomite rates at 0-15cm depth but it was not significant among treatment means. The highest value of pH was observed in T5 and it significantly varied from other treatments at 15-30 cm depth. The optimum range of pH for tea is 4.5 to 5.5 (Anon, 2000). Application of different rates of dolomite did not exceed that level. It may be due to the high buffering capacity of Ukuwela soil series (Liyanage, 2012). Some mechanisms which affect the soil pH could not be controlled under field trial such as oxidation of applied N fertilizers, exchangeable acidity, washing out of dissolved cations, leaching of Ca and Mg due to the nature of the trial in field level. Due to plant uptake of these cations can alter the pH and those affect the equilibrium of soil pH. When nitrogenous fertilizer of ammonical nature added to soil they are nitrified and nitric acid is liberated.

Table.1: Effect of application of different rate of dolomite on soil pH at 0-15 cm and 15-30 cm depths

Level of Dolomite (tons/ha/pruning cycle)	**pH (Water)**	
	0-15cm	**15-30cm**
T1-(0)	4.43[a]	4.33[b]
T2-(1)	4.42[a]	4.42[b]
T3 –(2)	4.47[a]	4.25[b]
T4-(3)	4.59[a]	4.48[b]
T5-(4)	4.63[a]	4.90[a]
LSD Value (<0.05% P)	0.25	0.408
CV %	2.97	4.84
P value	0.289	0.041

Means followed by the same letter in each column are not significantly different to LSD at 5% level.

Effect of application of different rate of dolomite on soil available phosphorus

Soil available P was significantly varied at 0-15 cm with the different rate of dolomite application (Table 2). Significant increase of plant available P (13.67mg/Kg) at 0-15cm was recorded in T4 while T5 had shown the highest available P in soil at 15-30cm depth. It is generally known that reduction of soil acidity leads to increased phosphorus availability (Gaume *et al*., 2001). Iljkic.,*et al* (2008) reported that the increasing rate of dolomite increase the pH as well as the availability of phosphorus on acid soils. Most acid soils contain low P in soil pool because that is greatly influenced by soil. Tea plants are well adapted to acid soils with high Al availability. Under this condition P availability is rapidly declined. The sufficiency range of P for tea is 15-20ppm (Zoysa and Ananthacoomaraswamy, 1995). But, the results of this study showed the highest mean value of available P as 13.63 ppm at 0-15 cm depth and 17 ppm at 15-30 cm depth . ERP is only source applied evenly to all plots to satisfy P requirement. Availability of P may be influenced by dissolution of ERP. ERP dissolution is high at optimum moisture and pH (< 5.5) level (Zoysa *et al.* 1998). Low moisture content in soil due to insufficient rainfall during experimental period to dissolve the ERP and plant uptake could be the possible reason for these declines.

Table 2: Effect of application of different rate of dolomite on soil available phosphorus

Level of Dolomite (tons/ha pruning cycle)	**P (mg/Kg)**	
	0-15cm	**15-30cm**
T1-(0)	6.00[b]	3.33[b]
T2-(1)	3.67[b]	3.33[b]
T3-(2)	3.67[b]	3.33[b]
T4-(3)	13.67[a]	4.00[b]

T5-(4)	7.67[a]	17.00[a]
LSD Value (<0.05% P)	6.163	3.47
CV %	47.21	29.74
P value	0.029	0.0001

Means followed by the same letter in each column are not significantly different to LSD at 5% level.

Conclusions

This study revealed that there was no significant difference in soil pH among different rate of dolomite applied at 0-15cm depth. Significant effect on pH with the different rate of Dolomite was found at 15-30 cm and highest soil pH was noticed with the highest dolomite applied plot. The P availability greatly influenced by soil pH. Application of 3tons dolomite/ha/pruning cycle had shown highest available P at 0-15 cm depth while application of 4tons dolomite/ha/pruning cycle had shown the highest available P in soil at 15-30 cm depth.

Acknowledgement

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Determinants of absenteeism in tea plantation workers (Case study in selected tea estate in Badulla)

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Introduction

Absenteeism is a common problem in many industrial units, small or big, private or Government. It can be defined as a single day of missed work (Martocchio&Jimeno 2003), an individual's lack of physical presence at a given location and time when there is a social expectation for him or her to be there (Martocchio& Harrison, 1993) or non-attendance of employee for scheduled work (Gibson 1966, john 1978). Concerning tea sector in Sri Lanka, chronic absenteeism is one of the major problems which may lead to out-migration in the long run (Institute of Social Development, 2008). The labour situation on plantations has gone from one of surplus to deficit, with an annual decline at the rate of 10% – 20% of the workforce (Institute of Social Development, 2008). This has caused the privatized large-scale plantation or estate to afflict with low productivity and high cost of production which resulted for continuous low profit margins (Institute of Social Development, 2008). Sri Lankan tea production is mainly concentrated into seven regions and Uva region is having nine sub regions. Among these, Telbadde estate is the largest entity in Badulla/Demodera/Hali-Ela sub region (Sri Lanka Tea Board). According to the estate reports, Telbadde estate has one of the largest working populations in this region as well as high rate of absenteeism. As the absenteeism has become problematic to the estate in the short run as well as long run, this study attempts primarily to identify the factors affecting the short run absenteeism.

Methodology

There are 161 holdings in estate sector all over the Badulla district (Statistical Information on Plantation Crops, 2012). Among them one of the largest entities is Telbadde estate employing 1346 workers with 464.50 ha of land extent. This estate manly consists with six divisions. COBO and Lower divisions are the farthest while Upper and West-Morland are the nearest divisions to the estate office.

Table 01: Worker population in the divisions

Division	Number of workers
Upper Division	293
Lower Division	163
Kendagolla Division	141
West-Morland Division	250
Malangamuwa Division	259
Cobo Division	149
Factory	91

Source: Progress Report – Telbedda estate, 2012

To find the determinants, primary data of 455 absentees for three months period were collected using a questionnaire survey covering all six divisions. A multiple regression model was used to find the determinants.

$$\boldsymbol{Y = \alpha + \beta_1 X_1 + \beta_2 D_1 + \beta_3 D_2 + \beta_4 X_2 + \beta_5 X_3 + \beta_6 D_3 + \beta_7 D_4 + \beta_8 D_5 + \beta_9 D_6 + \beta_{10} D_7 + \beta_{11} D_8 + \beta_{12} D_9 + + \beta_{13} D_{10} + \beta_{13} D_{11} + \varepsilon}$$

Y= Number of absent days (Number), $X_{1=}$ Age, $D_{1=}$ Gender (Dummy), $D_{2=}$ Marital Status (Dummy), $X_{2=}$ Number of family members (Number), $X_{3=}$ Number of dependent children (Number), D_3= COBO Division (Dummy), D_4= Upper Division (Dummy), D_5= Lower Division (Dummy), D_6= Malangamuwa Division (Dummy),D_7= Kendagolla Division (Dummy), D_8= West Morland Division (Dummy), D_9= Worker category (Dummy), D_{10}= 15 May - 15 Jun (Dummy), D_{11}= 15^{th} Jun - 15^{th} Jul (Dummy), α & β = Coefficients, ε = Random Error

Result and Discussion

Results of the regression analysis show that age of the absentee and dummy variables for COBO Division, Upper Division, Lower Division, West Morland Division and Worker category are significant at 95% confidence while the number of family members is significant at 90% confidence.

Table 02: Determinants of Absenteeism

Explanatory variables	Coefficients	SE Coef	T
Constant	5.5384**	0.8076	6.86
X1	-0.02505**	0.01105	-2.27
D1	0.0611	0.1919	0.32
D2	0.4735	0.367	1.29
X2	-0.2396*	0.1278	-1.87
X3	0.1566	0.122	1.28
D3	-0.7269**	0.3569	-2.04
D4	1.7014**	0.3994	4.26
D5	-0.898**	0.3646	-2.46
D6	0.4735	0.3799	1.25
D7	0.2593	0.4224	0.61
D8	3.1469**	0.3846	8.18
D9	-0.7727**	0.3542	-2.18
D10	-0.0072	0.2713	-0.03
D11	0.0381	0.2453	0.16

*and ** indicate significance at a 10% and 5% level, respectively.

The regression equation is

No of absent days = 5.54 - 0.0251 X_1-0.2396X_2 -0.7269D_3 + 1.7014D_4-0.898D_5+3.1469D_8-0.7727D_9

More specifically, the results indicate that the absenteeism is decreased with the age of the worker. In plantation sector most of the youngsters prefer to find work out of the estate as their interest in working in estates has lost due to several reasons such as low profile stigma, unavailability of suitable opportunities for educate youth etc. On the other hand this is an indication that more workers are old workers and their main occupation is estate employment in comparison to youth. It is a fact that the younger generation work on and off in estates until they get a better opportunity outside the estate. Family size is a major determinant and it negatively associates with absenteeism. When the Number of family members increases the workers have to earn more for their day –to –day expenses. Since the workers are paid on daily basis they try to earn more via attending frequently to work.

Upper division and West Morland division have the largest worker population in the estate as 293 and 250 respectively. Therefore, naturally the absenteeism is fairly high in those two divisions as it explains by the coefficients of the variables. Also these divisions are the closest to the estate office.

But COBO and Lower division shows a negative relationship with the absent days. These divisions are located in the ends of the estate which are farthest to the office. Therefore the absenteeism in divisions where it has more access to city and the facilities is higher than that of in farthest divisions with less access to the urban area.

Worker category variable consist of residents and non-residents. 91% from the working population in this estate are residents who live inside the estate. Therefore they have to attend for work in the estate as it is the main source of their living. Therefore the variable, worker category, shows negative relationship with number of absent days.

Conclusions

According to the results of the study the age, number of family members, divisions with largest worker population locating nearest to the office (Upper and West Morland) and divisions farthest to the office (Lower and COBO) and worker category are the determinants of absenteeism for the workers in the selected tea estate.

Acknowledgement

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Determinants of income diversification in Tea estates households in Badulla district

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Introduction

Tea is the main foreign exchange owner in Sri Lanka. It shows that Tea industry is playing major role in national economy. Estate laborers are one of the major players in tea industry. Tea industry economically depends on sweat and blood of estate workers (Muthulingam, 2010). In initial stage of tea industry, laborers who were working in tea industry had estate income as sole income source. If it was sole way of income, the labor wage was very low. They had not enough facilities to engage with other agricultural and non-agricultural like income activities. Also management of tea estates was provided facilities to estate households to work only in estates. To improve the estate workers living condition, there is an alternative way called as an income diversification. Income diversification has talked world widely with various sectors. But, no any research has carried out on income diversification in tea estate households. Therefore, study of this matter is most important to the tea estate sector. In this study the income diversification and pattern of income diversification of tea estates households are considered in Badulla district.

Materials and Methodology

The Survey was conducted in Badulla district by using 298 tea estates households. Censored Tobit regression analysis method was used to examine the determinants of income diversification. In many research on income diversification have used censored Tobit model to find out determinants of the income diversification. In this research dependent variables are including value zero to high amount of value. Therefore for Tobit model is used for data analaying. (Schwarz and Zeller, 2005). In this study three dependent variables are taken as estate income, other agricultural income and non-agricultural Income. Nine variables are used as explanatory variable. Those are age of household head, gender of household head, number of dependents in a family, number of male, number of female, monthly expenditure, distance to the city, years of schooling household head and loan receipt.

Results and Discussion

Table 03: Determinants of income diversification

Explanatory variables	Estate income	Other agricultural income	Non-agricultural income
	Coefficient	Coefficient	Coefficient
Number of dependent	-7871.379***	-2256.287**	-4596.131***
Number of male	5566***	87.8478	8231.956***
Number of Female	7416.034***	686.482	6434.544***

Monthly Expenditure	.2750591**	.2519957**	.1913611
Distance to City	133.5043	191.6546	-540.0511
Age of Household Head	-225.4097***	52.19788	279.7119***
Gender of Household Head	1307.716	1898.897	4320.42
Years of Schooling Household Head	-557.2577*	767.5238	629.9214*
Received of Loan	9767.181***	1926.039	-13556.9***

[Note: *** p< 0.01(99% confident interval), ** p< 0.05 (95% confident interval), *p< 0.1 (90% confident interval)]

The results in the table 01 shows that number of dependents of the family, number of males, number of females, monthly expenditure, age of household head, and household head year of schooling and received of loan were the significant factors affecting on estate income share in total income of estate households. Number of dependents has negative significant effect on the income generate from estate activities. Number of males and number of females have positive significant effect on income share from the estate activities. Monthly expenditure has positive significant effect on share of income received from the estate income. Age of household head has negative significant effect on the income share from the estate activities. Household head year of schooling has negative significant effect on the income share from the estate activities. Loan receipt has positive significant effect on the income share from the estate working. Above Tobit results further revealed that monthly expenditure, number of dependents and household head year of schooling were the significant factors that affecting on other agricultural income share in total income of estate households. Monthly expenditure has positive significant effect on income share from the other agricultural activities. Total dependents in a family have negative significant effect on the other agricultural income. Household head year of schooling has positive significant impact on the other agricultural income. According to the findings of Barratt et al. (2001), years of schooling household head has negative significant impact on other agricultural employment.

According to the table 01 number of dependent in a family, Number of males, number of females, age of household head, household head year of schooling and received of loan were the significant factors affecting nonagricultural income share in total income of estate households. Number of dependents has negative significant effect on the income share from the nonagricultural activities. Number of males and number of females has positive significant effect on income share from the nonagricultural activities. There is a positive significant effect on the income share from the nonagricultural activities by age of household head. In many literature findings shows that age of household head has positive significant impact on non-agricultural income. (Mishra et al., 2010; Olay, 2010; Abdulai and Delgado, 1999). Years of schooling of household head has positive significant effect on the income share from nonagricultural activities. Barratt et al. (2001) and Minot et al. (2003) also have found that years of schooling household head has strong positive relationship with the non-agricultural income. Receipt of loan has negative significant impact on the income share from the non-farming activities. It suggested households that share their income from the nonagricultural activities are not going to receipt of loans.

Number of dependent is the only one factor which influenced on the both estate income, other agricultural income and non-agricultural income.

Conclusion

Through this research we are mainly focused on the analyzing the determinants of tea estates households income diversification. This study showed that tea estates households in Badulla district had involved mainly in three income generating activities. Those are estate income, other agricultural income and non-agricultural income. The regression analysis revealed that diversification of income is determined by some socio economic factors. From those factors number dependents, number of males and females, monthly expenditure, access of loan, age of household head, years of schooling household heads are influenced on estate income. Other agricultural income activities are determined by monthly expenditure and years of schooling household head. Number of males and females, age of household head, years of schooling household head, number of children's, number of dependents and received of loan are determined the non-agricultural income. Only the Number of dependents is influenced on both estates, other agricultural and non-agricultural income activities.

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Investigating the Causes for Poor Control of *Erigeron sumatrensis* (Alawangupillu) by Glyphosate in the Uva Region

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Introduction

Erigeron sumatrensis (Alawangupillu) could be considered as a hard-to-kill weed in tea plantations because it has become totally resistant to Paraquat (Marambe et al, 2002) and from the recent past, there are claims that this weed shows a poor control also by Glyphosate (Prematilake, 2010). Recent investigations under upcountry conditions have shown that such poor control of weed is attributed to the dosages of Glyphosate applied and age or growth phase of weeds under up country conditions (Prematilake and Nawaratne, 2010 ; Prematilake and Darshani, 2011) . Hence, this study was aimed to determine the degree of control of *E. sumatrensis* weed at its different stages of growth by different dosages of Glyphosate under the conditions of Uva region.

Materials and Methods

Plants of *E. sumatrensis* at five different growth phases, having 3-5, 6-8, 9-11, 12-14 and more than 15 leaves per plant, were collated from Ury Estate, Passara (30 plants from each of the five growth phases) and planted them on a raised bed, randomly at a spacing of 50 x 50 cm. Plants were left on beds for 2 weeks period to establish. Plants of each of the five growth phases were treated with two dosages of Glyphosate (3ml/Land 5ml/L) at two weeks after planting. An untreated control was also maintained. A drenching application of Glyphosate was given to each plant during morning time using a hand sprayer. The experimental design was Complete Randomized Design with two factor factorial with 2 replications.Visual injury symptoms in the weed (chlorosis of leaves, wilting of leaves, drying and scorching of leaves and leaf fall) were observed and scored at 7, 14 and 21days after application (DAA). The degree of damage on leaves and whole plant was taken in to account in scoring using a scale (0 to 9).The viable plants were counted and the dry weight of above ground part and roots were measured at 21 DAA.

Results and Discussion

All visual symptoms such as chlorosis, wilting, scorching and drying of leaves and leaf fall were occurred at a higher intensity with Glyphosate at 5ml/L (2.75 L/ha) than the Glyphosate at 3 ml/L (1.65L/ha). Chlorosis of leaves and wilting of leaves were most prominent at seven DAA and scorching and drying of leaves and leaf fall prominent at 14 DAA.

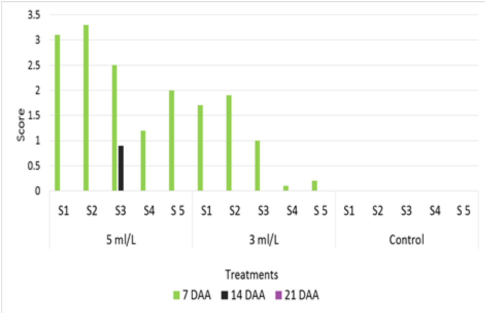

Fig 1: Chlorosis

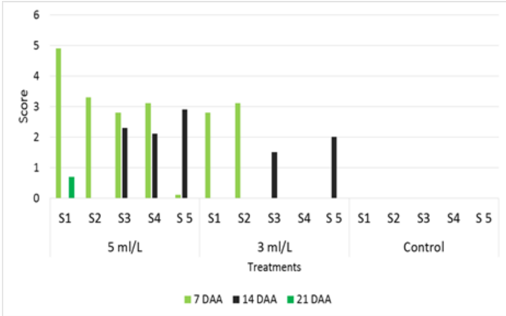

Fig 2: Wilting of leaves

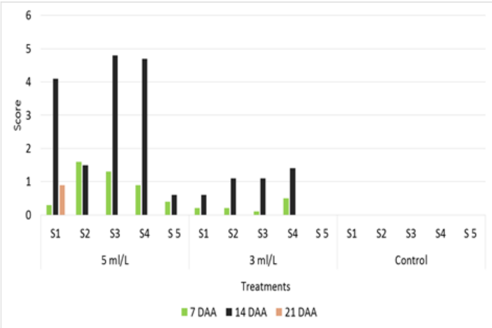

Fig 3: Scorching and drying of leaves

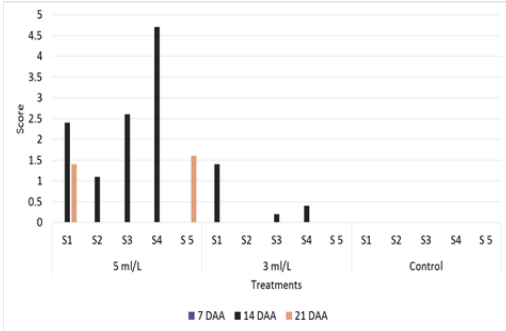

Fig 4: Leaf falling

The interaction effect between Glyphosate dosage and growth stages of *E. sumatrensis* on dead plant percentage and recovered percentage was significant ($p < 0.05$).

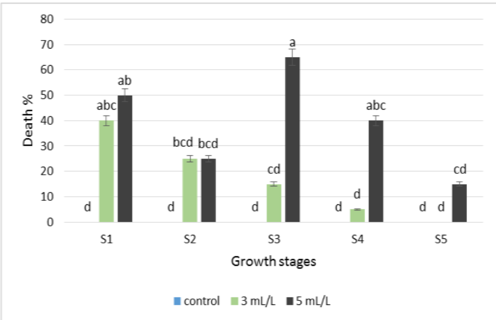

Fig. 5: Dead plant percentage

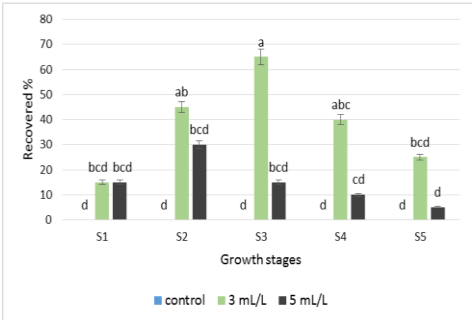

Fig. 6: Recovery percentage

The highest dead plant percentage was observed with 5ml/L (2.75 L/ha) Glyphosate compared to that of 3ml/L (1.65L/ha) Glyphosate. Furthermore, the highest dead percentage was reported from 9-11 leaf stage, and it was comparable at 3-5, 9-11 and 12-14 leaf stages. Highest recovery percentage was observed with 3 ml/L Glyphosate than that of Glyphosate at 5 ml/L at 9-11 leaf stage and it was comparable at 6-8, 9-11 and 12-14 leaf stage.

Dry weight of above ground part was not significantly affected by the dosage of Glyphosate at any of the growth phases. However, there was relatively a lower dry weight with Glyphosate at 5 ml/L than that of 3 ml/L. Similar to the dry weight of above ground parts there was no significant difference in dry weight of roots between the Glyphosate dosages at all the leaf stages and also compared with the control except 12-14 leaf stage. However, comparatively a lower dry weight was recorded with Glyphosate treatments than the control and comparatively lower dry weight with 5 ml/L than that of 3 ml/L of Glyphosate.

Table 1: Mean dry weight (g/ plant) of above ground parts of at different growth stages (*E. sumatrensis)* by different Glyphosate dosages at 21 DAA

Glyphosate dosage	**Mean dry weight of above ground parts at different growth stages (g/ plant)**				
	3-5 leaf stage	**6-8 leaf stage**	**9-11 leaf stage**	**12-14 leaf stage**	**Above 15 leaf stage**
5 ml/L	0.056^{e}	0.188^{de}	0.185^{de}	0.354^{cde}	0.728^{bc}
3ml/L	0.064^{e}	0.211^{de}	0.532^{bcd}	0.710^{bc}	0.917^{ab}
Control	0.061^{e}	0.254^{de}	0.343^{cde}	0.808^{b}	1.284^{a}

(In each column mean followed by the same letter are not significantly different at $p<0.05$)

Table 2: Mean dry weight (g/ plant) of roots of E. sumatrensis at different growth stages as affected by two Glyphosate dosages at 21 DAA

Glyphosate dosage	**Mean dry weight of roots at different growth stages (g/ plant)**				
	3-5 leaf stage	**6-8 leaf stage**	**9-11 leaf stage**	**12-14 leaf stage**	**Above 15 leaf stage**
5 ml/L	0.037^{f}	0.057^{f}	0.154^{cde}	0.162^{cd}	0.304^{ab}
3ml/L	0.055^{f}	0.073^{ef}	0.156^{cde}	0.234^{bc}	0.339^{a}
Control	0.086^{ef}	0.073^{ef}	0.223^{bc}	0.329^{a}	0.352^{a}

(In each column mean followed by the same letter are not significantly different at $p<0.05$)

Conclusion

E. sumatrensis can be controlled to a certain level with the use of higher dosages of Glyphosate exceeding 5 ml/L or 2.75 L/ha. Lower dosage of Glyphosate such as 3 ml/L or 1.65L/ha was sufficient to get good control. The maturity of the weed has some attribution to resist to Glyphosate herbicide. Thus 9-11 leafy stage and 3-5 leafy stages are found to be more susceptible phases of *E. sumatrensis* for Glyphosate when used at 5 ml/L or 2.75 L/ha. Finally can be suggested that further higher dosages of Glyphosate (>5 ml/L or 2.75 L/ha) could be tested for an effective control of *E. sumatrensis.*

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Clientele satisfaction towards the services rendered by government to the tea small holding sector

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Introduction

Tea is pre-eminent among Sri Lanka's plantation crops and it is one of the most important industries in the country in terms of employment and foreign exchange earnings (Basnayake , 2002). Next to China and India, Sri Lanka is the oldest tea producing country in the world producing nearly for 150 years (Asopa, 2004). Over the years, the word Ceylon has become synonymous with quality tea.

The entire economic base of the country was centered on the plantation sector at the time when Sri Lanka was gaining independence in1948; nearly 32% of GDP came from exports of plantation crops, which contributed 92% of the total export earnings. The development of the small holder sector, especially in the Low country helped to maintain the production level during the 1980's despite the deterioration of the estate sector production. The smallholder sector expanded very rapidly and presently accounts more than half (76%) of the total production.(Annual Report, Tea Small Holding Development Authority, 2012)

Small holders must receive current information and technology for effective management of their production, marketing and financial decisions. Individual characteristics of producers affect on the demand for information services while confidence in the information services is a central determinant of the frequency at which a producer refers to the services. (Yapa and Ariyawardana, 2005).Coupled with the information, financial support is vital to expand and maintain the tea production. This requirement is fulfilled through the subsidy policy of the government.

Tea small Holding authority is the institute established as the main supportive body to the small holding sector. Other institutions that are responsible for tea are, namely, Tea Research Institute, Sri Lanka Tea Board and Tea Commissioner's Department.

So the research was conducted to identify the satisfaction level of the small holders towards the services rendered by the government, to identify major factors that cause to farmers satisfaction, to evaluate strong and weak areas of the government service procedure and to make suggestions to overcome the weaknesses in government services.

Materials and methodology

Data were collected through a sample survey by giving structured questionnaire to randomly selected 150 small holders in 8 tea inspector's (TI) ranges at Badulla administrative district .

The degree of satisfaction of the small holders was the dependent variable and it was measured with respect to five different dimensions of the present government service. The dimensions considered were quality of the service, relevancy of technologies/service, competency of extension personnel, general usefulness/effect and characteristics of extension agent. Responses were obtained from five point Likert scale with scores of 5, 4, 3, 2, 1.

Coded and scored data were analyzed by Using SPSS software package. Based on mean and standard error, farmers were grouped in to three as less satisfied group, moderately satisfied group and highly satisfied group. The cut-off points for this categorization was derived by using the formula "mean (X) + or – 1.96 Standard Error (SE)" (V.S Sidhakaran, 2008).

Descriptive statistical techniques were used to present the demographic features of the sample. Simple correlation coefficient values were worked out to find out the strength of association between dependant variable and independent variables.

Multiple linear regression analysis was worked out to find out the contribution of independent variables to dependant variable. Age, Gender, Education level, farming experience, innovativeness, number of training attended, membership of a small holder association and contact intensity with an extension agent were selected as independent variables.

Results and Discussion

Larger proportion of respondents expressed low level of overall clientele satisfaction. Equal proportion of them was highly satisfied with the present government service procedure followed by less proportion of them moderately satisfied. This further indicates that there is a wide variation with respect to the clientele satisfaction levels.

Table 1: Distribution of small holders according to their overall clientele satisfaction levels towards the government services (n=150)

No	Overall clientele	Satisfaction	Number	Percentage
1	Low	<62.22%	58	38.66%
2	Medium	62.22%-69.48%	34	22.66%
3	High	>69.48%	58	38.66%

Table 2: Correlation of Independent Variables with the Dependent Variable

Variable	Description	Co-efficient
X1	Constant	1.00
X1	Age	0.15
X2	Gender	0.068
X3	Education Level	0.063
X4	Farming Experience	0.173*
X5	Membership of a small holder association	0.741**
X6	Frequency of meeting a extension Agent	0.824**
X7	Innovativeness	0.719**
X8	Communication channel usage	0.876**
X9	Time spend for tea cultivation	0.046

*Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level

Out of nine independent variable studied, only five variables farming experience, membership of a small holder association, frequency of meeting a extension agent, innovativeness, communication channel usage shows positive and significant association with the clientele satisfaction

Farming experience was significant under 0.05 significant level. It shows that there is a weak positive relationship between Overall clientele satisfaction and farming experience.

The variable, membership of a small holder association, frequency of meeting extension agent, communication channel usage and time spend for tea cultivation is significant at 0.01 significant levels. It shows that there is a strong positive relationship between overall clientele satisfaction and the mentioned variables.

Table 3: Regression Analysis of Factors affects on overall Clientele Satisfaction towards the Government Services

Variable No	Description	P value
	Constant	0.000
X1	Age	0.302
X2	Gender	0.840
X3	Education Level	0.766
X4	Farming Experience	0.233
X5	Membership of a small holder association	0.000
X6	Frequency of meeting a extension Agent	0.000
X7	Innovativeness	0.002
X8	Communication channel usage	0.000
X9	Time spend for tea cultivation	0.623

Table 3 reveals that out of nine independent variable studied, only four variables Membership of a small holder association, Frequency of meeting a extension Agent, Innovativeness, Communication channel usage shows positive and significant association with the clientele satisfaction at 5% significant level .

Conclusion

Based on the results of the study, it can be concluded that government services have been effective in creating general awareness on agricultural practices. The extension services have been helpful in solving agriculture related problems. Most of the services seem to be received on time. Extension personnel are competent in communication and they have been maintaining a friendly relationship with the farmers.

The findings suggest that there are several drawbacks in the government service procedure. The technologies and recommendations are cost ineffective and incompatible with socio-economic conditions. Clients are facing inconveniences when assessing to the service providing places such as TRI and sub office of TSHDA. Clients are not having a positive attitude towards the way of distributing the subsidies. Also there are some weakness in monitoring and evaluation after launching a new project.

Membership of a small holder association, Frequency of meeting a extension Agent, Innovativeness of the farmer, Communication channel usage are having positive relationship with clientele satisfaction.

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Firewood energy utilization in different dryers used in Tea processing

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Introduction

Tea industry is one of the most key important drives in Sri Lankan economy. Sri Lanka Sustainable Energy Authority is one of the important government institutions for energy management and enhancing awareness and creating technical capacity on energy conservation in Sri Lanka. Tea industry utilizes both electrical and thermal energy for its processing. The tea factories pre-dominantly use fuel wood to meet their thermal energy needs, in the drying process, which is the major transformation process in the tea industry. The lack of researchers on the energy utilization of different dryers used in Sri Lankan tea industry and different types of dryers are used depending on the production capacity of the tea factory.

The objectives of the research are to find out firewood energy utilization of different dryers and performance of different dryers in Sri Lanka.

Materials and methodology

The research was carried out to Sustainable Energy Authority during the period from April to August 2014. Specific thermal energy utilization (MJ/kg) was used to measure the level of firewood consumption for dryers and it was tested for different dryers, location and combustion technology. Two factor factorial design was implemented as the experimental design where dryer type and combustion technology were taken in to consideration .There are three types of dryer commonly used in tea drying such as, conventional endless chain pressure type dryer (ECP), Fluidized bed drier (FBD), and combination drier which works on a combination of ECP and FBD principles .There are two types of combustion technologies used for tea drying such as, Boilers and furnace. Primary data were collected from factory officers by providing the structural questionnaires. Secondary data were also collected from the annual reports of Sri Lanka Sustainable Energy Authority and factory reports of different tea factories. Collected sample was surveyed based on the factory records during 2012 to 2013 to gather necessary information. Factory observations were also was carried out to confirm the accuracy of data that were collected by the interviews of factory officers and Factory managers.

Minitab 16 Statistical Software was used for both descriptive and interferential statistics. ANOVA General linear model was used to analyze the variance of dryer output in relation to dryer types and combustion technology. Collected data were analyzed using descriptive statistical methods. Descriptive statistics were graphical explained with using of Microsoft Excel and Minitab software. Pearson correlation was used to determine the association of consumption of firewood and total production. The relationship of firewood consumption and total production were analyzed by using simple regression technique.

Results and Discussion

According to descriptive statistics, firewood Energy Source was highly used in tea processing. The result revealed that, 19% firewood and saw dust, 8% firewood and furnace oil, only 3% of firewood and coconut shell was also used. Jungle wood was highly used in tea processing. The results showed that 36% rubber firewood and only 19% rubber and jungle wood were also reported.

The low country and mid country tea factories use only firewood and saw dust. But up country tea factories use different types of energy sources. Up country tea factories mainly use Fluidized Bed dryers and mid country and low country highly use Endless Chain Pressure dryers. Low country and up country mainly trended in small scale production and mid country highly trended in large scale production. In mid country, it is available large, medium and low price firewood. But in up country and low country, it is available only large and medium price fire wood.

The Endless Chain Pressure dryer was the highly used dryer type.it was revealed that, 28% of Fluidized Bed dryers and only 25% of combination dryers were also used in tea processing. Endless Chain Pressure dryers had the dryer capacity of 180-280 kg/hr, Fluidized Bed dryers had 280-500 kg/hr and Combination dryers had 250-450 kg/hr capacity. Endless Chain pressure Dryers are easy to be maintained than others. Endless Chain Pressure dryers were mainly used in small scale production, Fluidized Bed dryer and Combination dryers were highly used in large scale production in tea factories.

The furnace combustion technology was highly used in tea processing. 61% furnace and only 39 % of boilers were reported. Majority of tea factories in small scale production use furnace and tea factories in large scale production use boilers. Majority of low country and mid country tea factories use furnaces and up country tea factories use boilers and prominently Endless Chain Pressure dryers utilize the energy of furnace and Fluidized Bed dryers use the energy of boilers.

When consider the Regression output, P value 0.000 of the model suggests that at 5% significant level, firewood consumption is significant in relation to the dryer made tea production. R – Square was recorded as 49.3 % and it implies that 49.3% of the firewood consumption is explained by the made tea while the 50.7% is explained by unexplained variables.

Table1: Firewood Energy Utilization of Different Dryers and Combustion Technology.

Dependent Variables	Independent Variables	P Value
Firewood Energy Utilization	Dryer types	0.078
	Combustion Technology	0.398
	Dryer types*Combustion technology	0.209

According to ANOVA Analysis, P value > 0.05, there is no significant different of dryers firewood energy utilization mean. So there is no effect of dryer types and combustion technology for dryer firewood dryer firewood energy utilization.

Conclusion

The outcome of the study revealed that, about 70% of firewood and 44.4% jungle wood are mainly used for the dryers used in the thermal energy. Majority of the studied tea factories use Endless Chain Pressure dryers (47%) and the furnace combustion technology (61%).

Endless Chain Pressure dryers are mainly used in small scale production and Fluidized Bed dryer and the Combination dryers are highly used in large scale production. The low country and up country factories function towards a small scale production and while the mid country factories towards a large scale production. Majority of small scale production tea factories use furnace and large scale production tea factories use boilers.

The types of the dryers and the combustion technology do not affect significantly for the firewood energy utilization.

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Protocol for callus induction of *Camellia japonica* L. (Tea rose)

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Introduction

Camellia japonica (the Japanese Camellia) is one of the best known species of the genus *Camellia*. Among the *Camellia* species, the economic value of the *C. japonica* ranks the highest due to its beautiful ornamental flowers, edible uses (dried flowers, oil), medicinal uses (astringent, antihaemorrhagic, haemostatic, salve and tonic) and material uses (dye, oil) (Salinero *et al.*, 2012).

Although *C. japonica* has a high ornamental and medicinal value, it is not popular in tea cultivating tropical agricultural country like Sri Lanka yet. Further, it was revealed that the difficulties of propagating Tea Roses are significant and therefore growers discourage to propagate them. Also C. *japonica* multiplication and improvement through seeds is rare due to poor seed set in the white and pink varieties present in Sri Lanka. *C. japonica* is usually propagated only using stem cuttings in Sri Lanka at present. But rooting was very poor in both pink and white varieties (Fernando and Alwis, 2013). But a good economic potential can be achieved in Sri Lanka due to its beautiful ornamental flower which is having long life span if it is scientifically developed to get different colors and shapes. Therefore, it is very important to *in vitro* propagation of *C. japonica* in large scale to commercially enhance its real value especially in the up country and mid country regions of Sri Lanka.

Therefore this study was aimed to develop a protocol to induce the callus culture of *Camellia japonica* L (Tea Rose).

Material and Methods

This research study was conducted at Tissue Culture laboratory at Uva Wellassa University during the period of 22.04.2014 to 15.08.2014. The explants were collected from the Ury estates in Balangoda Plantations and Hakgala Botanical Garden, Hakgala, Nuwara Eliya.

This study was conduct to develop an efficient protocol for rapid and prolific callus induction of *Camellia japonica* (Tea Rose). In the first experiment, leaves and nodal segments used as explants. Nine different combinations of 20% sodium hypochlorite for three different time durations (20 minutes, 30 minutes, 40 minutes) and 70% ethanol for three different time durations (30 seconds, 1 minute, 1 and half minutes) were used to select the best sterilization method. Number of contaminated vessels were counted after one week. Above nine treatment combinations were succeeded only for *C. japonica* leaves. Because of again used another nine different treatment combinations for surface sterilization of nodes by adjusting soaking time duration in the 20% sodium hypochlorite (35 minutes, 40 minutes, 45 minutes).

In the second experiment, leaves, nodal segments and un opened flower bud flower petals used as explants. The sterilized explants were cultured on MS medium with three different hormone combinations of 3-indolebutric acid (IBA) and 6-benzylamino purine (BAP) to investigate the effect on callus induction.

Table 1: Nine different treatment combination used for callus induction of white and pink varieties of *Camellia japonica*

Medium / Explant	Leaves	Nodal Segments	Petals
MS + 1mg/L IBA+2mg/L BAP	T_1	T_4	T_7
MS + 1mg/L IBA+3mg/L BAP	T_2	T_5	T_8
MS + 1mg/L IBA+4mg/L BAP	T_3	T_6	T_9

Shortest time duration was recorded as minimum number of days for callus initiation for each treatment separately. After three weeks from establishment of explants morphology of callus was observed.

Results and Discussion

Selection and Preparation of Explants

Developmental stage of an explant is an important factor for initiation of cultures for *in vitro* propagation. Younger the tissues better the *in vitro* response. Age of stock plant, physiological age of the explant and its developmental stage, as well as its size can determine the success of a procedure. Mature plant derived explants reported to be highly recalcitrant *in vitro*. Moreover, high degree of contamination in mature tissues poses problem in the establishment of culture. Juvenile explants are more responsive in culture than the mature explants from mature trees (Ahuja, 1993).

Accordingly, young, disease free, healthy fully expanded light green color leaves and light brown color nodal segments were selected as explant.

Experiment 1

Table 2: Contamination percentages of C. japonica leaves

Treatment	Contamination %
20% NaOCl for 20 min + Ethanol for 30 seconds (T_1)	90%
20% NaOCl for 20 min + Ethanol for 60 seconds (T_2)	50%
20% NaOCl for 20 min + Ethanol for 90 seconds (T_3)	50%
20% NaOCl for 30 min + Ethanol for 30 seconds (T_4)	60%
20% NaOCl for 30 min + Ethanol for 60 seconds (T_5)	40%
20% NaOCl for 30 min + Ethanol for 90 seconds (T_6)	40%
20% NaOCl for 40 min + Ethanol for 30 seconds (T_7)	40%
20% NaOCl for 40 min + Ethanol for 60 seconds (T_8)	20%
20% NaOCl for 40 min + Ethanol for 90 seconds (T_9)	40%

Contamination percentages of *Camellia japonica* leaves in each treatment were showed in table 2. The results showed that 20% NaOCl for 20 minutes with 70% ethanol for 30 seconds showed 90% contamination. All other treatments showed the contamination, below 60%. Among the nine treatments 20% NaOCl for 40 minutes with 70% ethanol for 60 seconds showed the lowest contamination percentage (20%) for leaves. That was acceptable for sterilization of leaves (T_8).

Table 3: Contamination percentages of *C. japonica* nodal segments

Treatment	Contamination %
20% NaOCl for 20 min + Ethanol for 30 seconds (T_1)	100%
20% NaOCl for 20 min + Ethanol for 60 seconds (T_2)	80%
20% NaOCl for 20 min + Ethanol for 90 seconds (T_3)	100%
20% NaOCl for 30 min + Ethanol for 30 seconds (T_4)	100%
20% NaOCl for 30 min + Ethanol for 60 seconds (T_5)	100%
20% NaOCl for 30 min + Ethanol for 90 seconds (T_6)	100%
20% NaOCl for 40 min + Ethanol for 30 seconds (T_7)	90%
20% NaOCl for 40 min + Ethanol for 60 seconds (T_8)	80%
20% NaOCl for 40 min + Ethanol for 90 seconds (T_9)	70%

Contamination percentages of *Camellia japonica* nodes in each treatment were showed in table 3. The results revealed that all treatments showed more than 70% contamination for nodal segments. T1, T3, T4, T5, T6 shows 100% contamination for nodal segments. That was doubtful for surface sterilization of nodal segments. None of surface sterilization method could be recommended. Therefore, again another nine different treatment combinations were used for surface sterilization of nodes by adjusting soaking time duration in the 20% sodium hypochlorite. Table 4 shows the results of adjusted treatments.

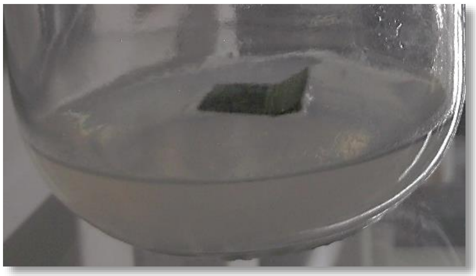
Table 4: Contamination percentages of *C. japonica* nodal segments

Treatment	Contamination %
20% NaOCl for 35 min + Ethanol for 30 seconds (T_1)	100%
20% NaOCl for 35 min + Ethanol for 60 seconds (T_2)	90%
20% NaOCl for 35 min + Ethanol for 90 seconds (T_3)	90%
20% NaOCl for 40 min + Ethanol for 30 seconds (T_4)	80%
20% NaOCl for 40 min + Ethanol for 60 seconds (T_5)	90%
20% NaOCl for 40 min + Ethanol for 90 seconds (T_6)	80%
20% NaOCl for 45 min + Ethanol for 30 seconds (T_7)	90%
20% NaOCl for 45 min + Ethanol for 60 seconds (T_8)	70%
20% NaOCl for 45 min + Ethanol for 90 seconds (T_9)	30%

Contamination percentages of *Camellia japonica* nodes in each adjusted treatments were showed in table 4. The results revealed that among the nine treatments only one treatment (T_9) showed 30% contamination where as all the other eight treatments showed more than 70% contaminations. 20 % NaOCl for 45 minutes with 70% ethanol for 90 seconds showed the lowest contamination (30%) for nodal segments of *C. japonica.* Thus T9 was accepted for surface sterilization of nodal segments of *C. japonica.*

Seran *et al.* (2007), Bidarigh and Azarpour (2013) reported that the surface sterilization of *Camellia sinensis* leaf and nodal explants were treated with 70% ethyl alcohol for two to three minutes time duration and 20% sodium hypochlorite for 30 minutes. The surface sterilization of the present study was strongly success with the using above chemicals with changing soaking time duration. 20% NaOCl for 40 minutes and ethanol for 60 seconds for leaves and 20% NaOCl for 45 minutes and ethanol for 90 seconds for nodal segments were succeeded for surface sterilization of *Camellia japonica*.

Browning Effect of Explant in Culture Establishment



(a) **(b)**

Plate 1: Browning of explants (a) Just after establishment of the explant b) Browning after establishment of the explant

One of the most common problems associated with the *in vitro* establishment of *Camellia japonica* is the deleterious effects of oxidized phenols (Forrest, 1969).The oxidation of exuded phenolic cause darkening or browning of explants of *Camellia japonica*. Leaf explants margins were light brown in the beginning, after it has become dark brown. Some leaf explant totally became brown color after the establishment and the oxidation of exuded phenolic cause browning of culture media after established the explants of *Camellia japonica* as shown in plate 1.

Experiment 2

Callus were initiated from *Camellia japonica* leaves and nodal segments, but among the three explants, flower petals did not respond to any of the treatment tried for callus initiation.

The minimum number days to callus initiation was 25 days from the leaves on Murashige and Skoog medium (MS) supplemented with the 1mg/L IBA + 4mg/L BAP (T3). Color of leaf pieces turned into light yellow in the beginning and gradually became dark brown and then initiated callus from the uncut surfaces.

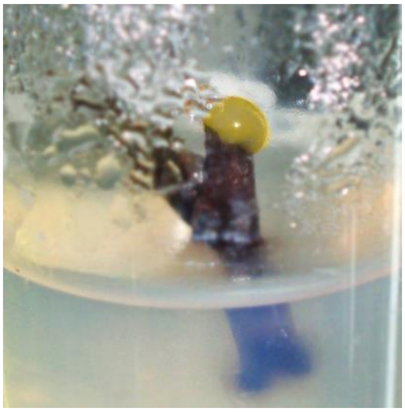
Plate 2: Calli of leaves after three weeks

Leaves callus tissue was yellow in the beginning, it has become friable and greenish patches appeared on the top of the callus. Friable in texture and irregular shaped calli formed from *C. japonica* leaves explants.

The minimum number days to callus initiation was 19 days from the nodal segments on MS medium supplemented with the 1mg/L IBA and 2mg/L BAP (T4). MS medium supplemented with 1 mg/L

IBA and 3 mg/L of BAP (T5) took 23 days to initiate the calli. The minimum number days to callus initiation was 25 days from the leaves on MS medium supplemented with the 1mg/L IBA + 4mg/L BAP (T3).

(a)



(b)

Plate 3: Nodal callus (a) Initiated calli of nodal segments after three weeks (b) Calli of nodal segments after four weeks

The color of nodal segments turned in to brownish orange and gradually became light yellow and then initiated callus from cut surfaces. When the callus aged, nodal callus was appeared as light yellow in color, watery and soft in texture and globular shaped.

Arulpragasam *et al.* (1988) reported on the successful production of callus from the tissues of cotyledons, nodal segments with axillary buds and leaves of *Camellia sinensis*. In the present study nodal segments with axillary buds and leaves of *C. japonica* were found effective explants for callus initiation.

Camellia sinensis friable calli were first initiated on cultured leaf segments in the presence of BAP (2.0 mg/L) and NAA (3.0 mg/L) after 21 days of incubation. A combination of BAP (2.0 mg/L) and NAA (1.0 mg/L) also induced greenish yellow friable calli but at a low frequency (Seran *et al.,* 2007). In the present study, MS supplemented with 4mg/L BAP and 1mg/L IBA was found effective for leaf callus formation of *Camellia japonica*. Callus color also greenish yellow and minimum number of days for callus initiation was 25 days. This is in accordance with the findings of Seran *et al.* (2007).

Conclusion

According to the results obtained, the protocol developed for initiation of the callus culture of *Camellia japonica;*

Semi mature light brown nodal segments (1cm) and light green leaves ($1cm^2$) as explant are favorable to induce callus on MS medium.

Camellia japonica leaves can be treated with 20% NaOCl for 40 minutes and 70% ethanol for 60 seconds (T8) and nodal segments can be treated with 20% NaOCl for 45 minutes and 70% ethanol for 90 seconds (T9) for proper surface sterilization.

MS supplemented with 0.9% agar, 3% sucrose, 0.001% myo-inositol, with 1mg/L IBA and 2mg/L BAP or 1mg/L IBA + 3mg/L BAP is better hormone combination for earlier callus formation from *Camellia japonica* nodal segments and MS supplemented with 0.9% agar, 3% sucrose, 0.001% myo-inositol, with 1mg/L IBA and 4mg/L BAP is better hormone combination for earlier callus formation from *Camellia japonica* leaves. Among the different explants, nodal segments with axillary bud is the best explant for earlier callus formation for *Camellia japonica*.

Vertically placed nodal segments and leaves with a cut surface in contact with the medium is better for callus induction. Cultures should be maintained at 25±2°C temperature under completely dark conditions in an incubator. The callus formed should be subcultured on the MS medium of same combination after two weeks of induction.

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Distribution and accumulation of selected heavy metals in Tea plants

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Introduction

Tea (*Camellia sinensis (L.) O.* Kuntze) is the mostly consumed beverage in the world after the water. Currently, as a natural beverage, its demand is increasing drastically all over the world. But, with the reporting of contamination of tea from different hazardous (Heavy metal, pesticides…*etc*.), which cause adverse health consequences to human being, the attention for food safety regulations are being promoted by the different counties to protect their people. As a result different quality assurance and food safety regulations and certifications such as ISO, HACCP, GAP, MRL, Acceptable limits for heavy metals …*etc.* have been introduced to the tea industry also.

At field level due to usage of agricultural fertilizers and pesticides, migration of contaminants into a non-contaminated land as vapors and leach through soil, or as dust, or spreading of sewage sludge…*etc* cause to contamination of tea from above mentioned hazardous. Among them, contamination of tea from heavy metals has a critical issue. According to Sri Lanka Tea Board Standard acceptable limits for Fe - 500, Cu – 100, Pb – 2, Zn – 100 and Cd – 0.2 mg/kg and each country sets its own allowable limit for heavy metal in made tea.

Hence, this research was carried out as a primary study to find out the how those heavy metals are being (zinc, copper and lead) distributed and accumulated in tea plants and the impact of Glyphosate application for distribution and accumulation of those heavy metals. The ability of plants to tolerate and accumulate heavy metals can be assessed using Translocation factor (TF) which is defined as the ratio of metal concentration in the shoots to the roots ([Metal] Shoot/ [Metal] Root). Hence, Translocation factor was calculated for each treatment and metal also.

Material and Methods

Experimental unit were 18 months old tea plants (TRI 4052) which were planted in pots and for 45 days experiment was carried out in a shade house of Uva Wellassa University, Badulla. Research design was Complete Randomized Design. Control (Distilled water), Glyphosate (20 µl per pot) and heavy metal mixture (Zinc 300, copper 300 and lead 200 mg/kg per pot) were applied to plants diluting in 500 mL distilled water as treatments. Number of replications were five. Concentrations of Zn, Cu and Pb were determined in shoots, mature leaves, stem, mature roots and feeder roots using Atomic Absorption Spectroscopy after digested them. Plant tissues were digested using wet digestion procedure, thoroughly washed (from the tap water and distilled water) tea plant parts were dried at 80 ^{o}C overnight. They were ground and sieved through 1 mm mesh. 0.5 g of sample placed in a small beaker and 5 ml of Con. HNO_3 was added. Then, it was kept for overnight to digest the organic compound in plant materials. Digested samples were heated on hot plate at 100 ^{o}C for three hours (until emission of NO_2 fumes has ceased). Each sample was diluted with 25 ml of distilled water and filtered through filter paper. Filtered transparent solution were analyzed using Atomic Absorption Spectrometry.

Result and Discussion

There was a significant difference ($p< 0.05$) between the treatments on accumulation of each heavy metal in different parts of tea plant. The treatment of Heavy metal mixture was significantly difference from other two treatments. And there was no any significant difference between the control and Glyphosate treatments on accumulation of Zn, Cu and Pb each part of tea plant.

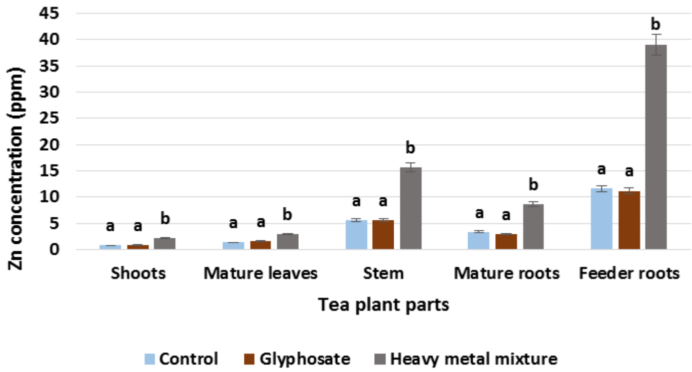


Figure 1. Zn accumulation in different parts of the tea plant

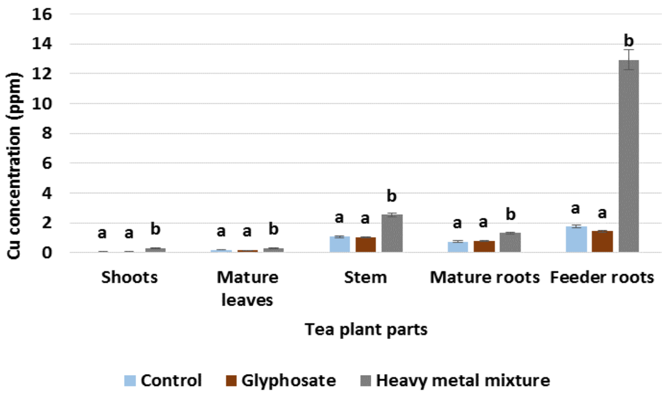
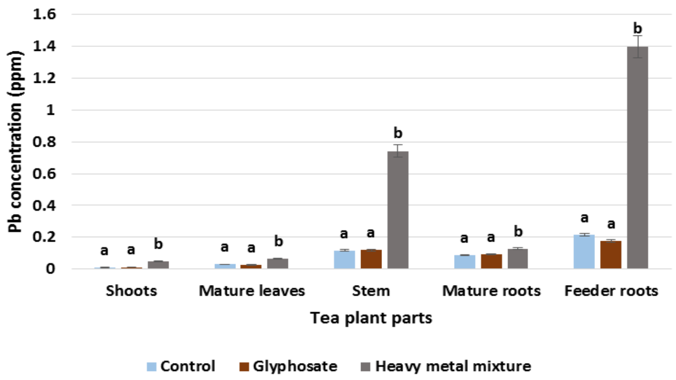


Figure 2. Cu accumulation in different parts of the tea plant



According to Figure 1, 2 and 3 the concentration of Zn, Cu and Pb in tea plants were in the order of: feeder roots > stems > mature roots > mature leaves > shoots. Most of the heavy metals were fixed in feeder roots and less amount of heavy metals transferred to the above ground parts. This implies that, there might be a mechanism to prevent heavy metals being transferred to above ground part in tea plants.

The ability of plant to tolerate and accumulate heavy metals can be assessed using Translocation Factor (TF). According to the Figure 4, it is reveal that there is a significant difference of TF values between the treatments in lead (Pb). Highest TF values were given by the Glyphosate treatments for all metals. Hence, it can be concluded that Glyphosate application has an impact on heavy metals distribution and accumulation and TF values in heavy metal mixture were lower than other treatments. It is further proved the mechanism that prevent heavy metals being transferred to the above ground parts in tea plant, under the condition of addition of external Zn, Cu and Pb to the soil.

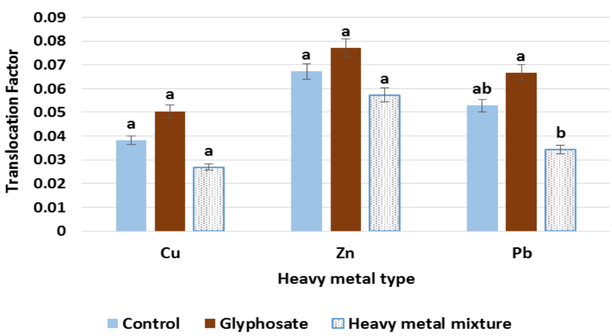


Figure 4. Translocation Factor in different treatments

Conclusion

Concentrations of Zn, Cu and Pb in tea plants from high to low levels follow the order: feeder roots > stems > mature roots > mature leaves > shoots. Feeder roots and stems were the main channels of Zn, Cu and Pb transmission in tea plants, and also the main accumulation parts and roots preserve the absorption of most Zn, Cu and Pb under the condition of addition of external Zn, Cu and Pb to the soil. Reference to TF values it can be concluded that there might be a mechanism to prevent heavy metals being transferred to the above ground part and Zn, Cu and Pb accumulation in different parts of tea plant was not significant in Glyphosate treatment compare to control. But, Glyphosate application has an impact on heavy metals distribution and accumulation in tea plant.

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