Crush Tear Curl (CTC) green tea processing: A modified form of green tea for the tea lovers

Abstract

An experiment was conducted following three factor factorial CRD to compare CTC green tea with conventional green tea on the basis of processing dynamics and biochemical characters of processed green tea as per the leaf standard of one leaf and a bud, two leaf and a bud and three leaf and a bud obtained from two tea clones namely TV1 and S_3A_3.Highest amount of polyphenol (245.65 mg g^{-1}) was recorded in case of steaming done for 4 minutes and processed by CTC method using one leaf and a bud of TV1. Lowest antioxidant activity, in terms of DPPH scavenging (%) was recorded (74.02%) in case of CTC green tea processed by steaming done for 6 minutes using three leaves and a bud of TV1. Highest amount of total flavonoid content (22.92 mg g^{-1} of QE) was found in case of Orthodox green tea using one leaf and a bud of S_3A_3 where roasting done for 4 minutes.

Keywords: CTC green tea; Orthodox green tea; Polyphenol; Flavonoids; Catechins

1. INTRODUCTION

CTC (crush, tear, curl) technology is widely used in black tea manufacturing process. The process involves five different steps consisting of withering, rolling, CTC, fermentation and drying. In the CTC step, the rolled leaves are subjected to crushing, tearing and curling in a CTC machine. The advantages of CTC black tea manufacturing are lower fermentation time and higher extraction efficiency. Very limited literatures are available where CTC step has been introduced for green tea processing. Barbora and Saha (1995) introduced CTC after the initial step of steaming or pan frying for green tea processing. The authors reported more cuppage and shorter processing period for CTC green tea (CGT) over OGT. However, no biochemical data on processing dynamics was reported on it till date. Kilel *et al.* (2013) also introduced CTC step in green tea processed from purple colored tea clones of Kenya. The study conducted by Deka *et al.* (2020) revealed that CGT had significantly high extraction efficiency of bioactive components than orthodox ones which led to a high content of total polyphenol, catechins, theanine andwater extract in CGT infusions. The extraction efficiency of total polyphenol, total catechin, theanine and water extract in CGT were 13.3, 7.5, 18.6, and 17.1%, respectively, higher in comparison to orthodox green tea. This study also provides a new fundamental basis of the economic efficiency of CGT in the light of the higher transfer rate of bioactive compounds from tea to its infusion.

Modification in the processing technique is the key to produce this unique form of tea. Production of CGT is a new concept and shall benefit the tea producers in near future. The existence of various tea cultivars under cultivation in North East India especially Assam, is believed to be highly rich in desirable bioconstituents. Different tea cultivars can provide high quality raw material for CGT production which will be a boon for the tea planters and the small tea growers. The present study is done to investigate the presence of total polyphenols, catechins, theanine, tannin, antioxidant activity, ash content, total flavonoids of processed green tea where the green tea leaves are plucked from the clones S_3A_3 and TV1.

2. OBJECTIVES

i) This study aims to guide a new product development in the form of granular green tea.
ii) Looking into its importance, the present study is undertaken with an objectiveto compare CTC green tea with conventional green tea on the basis of processing dynamics and biochemical characters.

3.METHODOLOGY

3.1 Geographical location

The study was conducted in the Tea Processing Unit of the Department of Tea Husbandry & Technology, Assam Agricultural University, Jorhat which is situated at 26°47' N latitude, 94°12' E longitude and with an altitude of 86.6 m above mean sea level.

General cultivation practices followed

Present investigation was carried out to study the processing technology of CTC green tea in terms of its biochemical characters and comparison was done with conventional orthodox green tea. The planting materials studied for the present investigation are TV1 and S_3A_3. These clones are being grown in Experimental Garden for Plantation Crops, Department of Tea Husbandry & Technology, AAU, Jorhat as per the standard practices of TTRI, Jorhat. The planting of these clones was done in the year 2002. The fertilizers used for manuring in the experimental plot were Urea, SSP and MOP in the ratio of 140:50:120. The fertilizers were applied in two splits – first in March/April and second in July/August. These clones were susceptible to Red rust, Red spider, Helopeltis and Jassid attack. PPC approved agrochemicals were used for management of insect, disease and weed infestation. Shade status maintained in the section had 30-40 % light interception.

Tea leaves were plucked manually from the experimental plot at 7 days interval during 2nd flush period (May/June) and processed in the same day at the Tea Processing Unit of the department. The number of leaf sample (for one clone + one leaf standard + two deactivation method + three different time interval of deactivation method + two processing method) is 12 for one replication. Plucking was done at 7 days interval which is a common practice in the tea plantations of North East India to ensure quality of the plucked tea leaves to produce tea of high quality (Baruah *et al.*,1986).

3.2 Preparation of green tea samples

Three different plucking standards of tea shoot such as one leaf and a bud (1 L + B), two leaves and a bud (2 L + B) and three leaves and a bud (3 L + B) were collected from Experimental garden for Plantation Crops, AAU, Jorhat during second flush period (May-June) for three consecutive years. All the fresh tea shoots were plucked from the same tea section under the same cultivation practices to specifically explore the influence of tea shoot maturity on the bio-chemical quality of green tea. The planting materials of tea plant were TV 1 and S_3A_3. Subsequently, the fresh tea shoots were processed into green tea samples through green CTC tea processing as well as conventional orthodox processing method in second flush period in the year 2020, 2021 and 2022.

3.3 Processing steps

Standard protocol for green tea manufacture was followed. Young tender shoots of one leaf and a bud (1 L + B), two leaves and a bud (2 L + B) and three leaves and a bud (3 L + B) were plucked separately and processed into OGT and CGT by following two methods given by Barbora and Saha (1995).

3.4 Analysis of biochemical characters

For studying the biochemical constituents of processed green tea samples, the manufacturing of both CGT and OGT was done as per the protocol mentioned above. The estimation of bio-constituents of manufactured tea under study were done with three replications.

3.5 Determination of moisture content

2.0 ± 0.01 g of the sample was taken into an aluminium dish and heated in an oven at 103°C ± 2.0°C for 4 hours in order to attain constant weight. The weight of the sample was recorded again and moisture content was finally estimated by deducting the final weight from the initial weight, calculated and recorded as a percent (Kingori *et al.*, 2019).

3.6 Determination of ash content (As per ISO specification)

A sample weight of 5 g was taken in a silica crucible and the sample was placed inside the muffle furnace. This was followed by ignition of the sample at a temperature of 525 ± 25°C for 30 minutes. The crucible was cooled in a desiccator and weight was recorded. The process of heating was repeated for 30 minutes and after cooling of the sample was done in the desiccators. Weighment of the sample was taken until the difference between repeated weighing was less than 1 milligram. The lowest weight was recorded.

3.7 Determination of total polyphenols

The determination of total polyphenol content refers to the method ISO 14502-1:2005 using the Folin-Ciocalteau reagent. Tea extract of 0.5 mL was diluted with distilled water and volume was made up to 50 mL. After that, 1 mL was taken out and put into a separate test tube which was followed by addition of 5 mL of 10 percent Folin-Ciocalteau reagent (diluted using distilled water). This was followed by vortexing of the sample for 5 minutes after that addition of 4 mL of 7.5 percent sodium carbonate solution was done.The sample was then kept in a dark room for 60 minutes. The absorbance of the sample was recorded at a wavelength of 740 nm using a UV-vis Spectrophotometer. Total polyphenol content was determined from the standard curve equation for gallic acid with a 10-100 mg L^{-1} concentration range.

3.8 Determination of antioxidant activity

Antioxidant activity was analysed using the reaction of DPPH binding. To prepare DPPH solution, 0.01183 g of DPPH was dissolved in 96 percent ethanol and volume was made up to 100 mL. From this stock solution, 2.5 mL was taken and mixed with 0.5 mL of aqueous extract of green tea. The sample was then kept for 16 minutes and after that absorption was recorded spectrophotometrically at a wavelength of 515 nm with 96 percent ethanol as a comparative solution (Kumazawa*et al.*, 2004).

3.9 Estimation of total flavonoids

The amount of flavonoid content in the aqueous tea extracts was determined by aluminium chloride colorimetric method (Bansode, 2014). 1 mL of sample extract was mixed with 3 mL of methanol, 0.2 ml of 10 % aluminum chloride solution. At sixth minute 0.2 mL of 1 M potassium acetate was added anddiluted with 5.6 mL of deionised water. The resulting mixture was kept for 30 minutes for incubation at room temperature. The absorbance of the sample was recorded at 420 nm spectrophotometrically. Quercetin was used as standard compound (1mg mL^{-1}) at concentrations of 5,10,15,20 and 25 mg $100mL^{-1}$ of quercetin were prepared in methanol. All the readings were recorded in triplicates. The results were determined from the standard calibration curve of quercetin and total flavonoid contents were expressed as quercetin equivalents (mg g^{-1} of Quercetin of extracted compound).

3.10 Statistical analysis

The mean data for each character were subjected to analysis of variance (ANOVA) for 3 factor factorial CRD using OPSTAT software for 2 treatments (Leaf standard and Processing Methods) where green tea was manufactured from three different tea shoots such as one leaf and a bud (1 L + B), two leaves and a bud (2 L + B) and three leaves and a bud (3 L + B) of the clone S_3A_3. Samples were also prepared from the clone TV 1 by following the same protocol. The treatment mean squares were tested for significance by F –test and the difference of treatment means were tested by estimating the critical difference (CD).

Figure 1. The appearance of CTC green tea (CGT) and orthodox green tea (OGT). (a) Roasting Time : 4 Minutes, Clone S_3A_3 Leaf standard : 2 L + B; (b) Steaming Time : 5 Minutes, Clone S_3A_3, Leaf standard : 2 L + B; (c) Roasting Time : 4 Minutes, Clone S_3A_3, Leaf standard : 2 L + B

(a)

(b)

(c)

4. RESULTS

The results of the biochemical parameters studied are presented below.

4.1 Moisture content

The present study revealed that moisture content in all the samples lies within the standard limit. However, lowest moisture content (3.014%) was recorded in case of CGT processed by roasting done for 6 minutes using three leaves and a bud (3L+B) of TV1 (Table 1). Introduction of CTC step in green tea processing resulted granular form of green tea which facilitated maximum exposure of tea particles to hot air during drying process. Roasting of tea leaves for 6 minutes at initial stage of green tea processing is additionally responsible to cause moisture loss. The values of moisture content decreased gradually from one leaf and a bud to three leaf and a bud in all the observations (i.e., young to mature leaves). This is similar with the finding of Harler (1964). The variation in moisture may be attributed to the degree of drying type and nature of tea involved (Kumar *etal.*, 2005). Very long firing or firing at very high temperature, however, impairs quality.

Table 1. Moisture content (%) of CTC green tea (CGT) and Orthodox green tea (OGT) processed by steaming and roasting method

Clone	Leaf standard	Steaming						Roasting					
		CGT			OGT			CGT			OGT		
		2 min.	4 min.	6 min.	2 min.	4 min.	6 min.	4 min.	5 min.	6 min.	4 min.	5 min.	6 min.
TV 1	3 L + B	3.265	3.248	3.526	4.830	5.326	5.426	3.156	3.254	3.014	4.626	4.258	4.270
	2 L + B	3.352	3.368	3.424	5.352	5.454	5.326	3.386	3.462	3.026	5.524	5.245	5.014
	1 L + B	3.458	3.251	3.294	5.524	5.762	5.802	3.454	3.352	3.210	5.458	5.624	5.350
S_3A_3	3 L + B	3.054	3.208	3.384	5.354	5.654	5.824	5.480	4.854	4.524	4.854	4.450	4.165
	2 L + B	3.248	3.452	3.302	5.563	5.754	5.586	4.367	4.520	4.156	5.268	5.012	4.246
	1 L + B	3.426	3.628	3.846	4.917	5.326	5.524	4.160	4.012	3.647	5.142	5.348	4.158
Factors		Clone	Time	Leaf standard	Clone	Time	Leaf standard	Clone	Time	Leaf standard	Clone	Time	Leaf standard
$CD_{0.05}$	Factor	NS	NS	NS	NS	0.154	NS	0.106	0.130	0.130	0.130	0.160	0.160
	Interaction	NS			NS			0.318			NS		

N.B. L: Leaf; B: Bud

4.2 Ash content

Ash content of processed tea is also a vital parameter of quality. The ash content in tea is an indication of its mineral content; however, it does not necessarily indicate high quality except when there is a favorable balance of the essential minerals (Ahmed and Stepp, 2013). Presence of high amount of ash in tea may be due to less amount of moisture in tea. Total amount of ash has been associated with mineral content of tea. Ash refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter. High ash content suggests that it is a good source of minerals.

In the present investigation, it was observed that ash content was more in OGT than CGT irrespective of deenzyming method. Highest content of ash (6.026 %) was found in case of OGT processed by roasting done for 6 minutes using three leaves and a bud of TV 1. However, lowest ash content (3.235 %) was recorded in case of OGT processed by steaming done for 2 minutes using one leaf and a bud of TV1 (Table 2).

It is expected that the amount and composition of ash remaining after combustion of manufactured tea varied considerably according to the leaf age, processing method etc. It was observed that longer the length of roasting time, higher the ash content in roasted green tea. It was also observed that increase in roasting time caused increase in roasting temperature. This is in accordance with the statement of Sudarmadji (1989) that the ash content contained in the material depends on the type of material, the time and temperature used at the time of processing, and the lower the non-mineral components contained in the material, the more it will increase the percent ash relative to the material.However, increasing trend of ash content was also observed in case of steamed green tea but it was lesser than roasted green tea. The study also revealed that a significant difference in the ash content of green tea samples was found according to planting material and leaf standard. However, there was no significant difference observed in case of green tea processed by steaming and roasting method. The interaction between the clones, processing methods and leaf standards had been found to be non-significant in case of both CGT and OGT.

Table 2. Ash content (% dry weight) of CTC green tea (CGT) and Orthodox green tea (OGT) by steaming and roasting method

Clone	Leaf standard	Steaming						Roasting					
		CGT			OGT			CGT			OGT		
		2 min.	4 min.	6 min.	2 min.	4 min.	6 min.	4 min.	5 min.	6 min.	4 min.	5 min.	6 min.
TV 1	3 L + B	5.245	5.286	5.354	5.428	5.468	5.520	5.468	5.621	5.896	5.604	5.866	6.026
	2 L + B	4.726	4.605	5.154	5.025	5.126	5.316	5.185	5.356	5.654	5.456	5.662	5.846
	1 L + B	3.235	3.294	3.365	4.856	4.918	4.974	3.025	3.462	3.248	3.142	3.245	3.465
S_3A_3	3 L + B	4.389	4.450	4.614	4.568	4.752	4.624	4.964	4.786	5.126	5.865	5.656	5.926
	2 L + B	4.176	4.206	4.298	4.354	4.458	4.602	4.632	4.524	4.732	5.254	5.465	5.626
	1 L + B	3.925	4.102	4.186	4.268	4.484	4.526	4.246	4.486	4.756	4.826	5.025	5.428
Factors		Clone	Time	Leaf standard	Clone	Time	Leaf standard	Clone	Time	Leaf standard	Clone	Time	Leaf standard
$CD_{0.05}$	Factor	0.198	NS	0.243	0.207	NS	0.253	0.215	NS	0.298	0.250	NS	0.306
	Interaction	NS			NS			NS			NS		

N.B. L: Leaf; B: Bud

4.3 Total polyphenol content

From the findings it was observed that with increase in leaf age, there was decrease in total polyphenol content in processed green tea and significant difference was recorded for the same in clones, leaf standard and processing methods. Highest amount of polyphenol (245.65 mg g-1) was recorded in case of steaming done for 2 minutes and processed by CTC method using one leaf and a bud of TV 1. However, lowest polyphenol content was recorded in case of roasted CTC green tea using three leaves and a bud with 5 minute roasting time (Table 3).

Degradation of polyphenol was more in case of roasting irrespective of roasting time. It may be due to high temperature development during roasting process. The interaction among clone, processing method and leaf standard had a significant effect on total polyphenol content of CGT as well as OGT as shown by the analysis of variance.

The present study revealed that the total polyphenolic content to be in the range of 224.32 to 245.65 mg g-1 in roasted and steamed green teas respectively. It was observed that with increase in shoot size, there was significant decrease in total polyphenol content in the processed green tea irrespective of deenzyming method. Sanyal (2016) reported that there was reduction of polyphenolic content in processed tea with increase in shoot size.

The present investigation also revealed that total polyphenol content was less in roasted green tea than steamed green tea irrespective of planting material. Lowest content of total polyphenol (224.32 mg g-1) was found in case of roasted green tea processed by CTC method. With increase in roasting time, there was reduction in polyphenol content in both orthodox and CTC green tea.

Table 3. Total polyphenol content (mg g^{-1}) of CTC green tea (CGT) and Orthodox green tea (OGT) processed by steaming and roasting method

Clone	**Leaf standard**	**Steaming**						**Roasting**					
		CGT			**OGT**			**CGT**			**OGT**		
		2 min.	**4 min.**	**6 min.**	**2 min.**	**4 min.**	**6 min.**	**4 min.**	**5 min.**	**6 min.**	**4 min.**	**5 min.**	**6 min.**
TV 1	3 L + B	234.38	233.45	231.65	237.65	235.68	234.24	231.46	228.64	226.38	233.62	231.28	230.14
	2 L + B	242.74	240.16	238.36	244.38	243.52	241.28	235.65	233.42	230.48	238.44	236.45	234.14
	1 L + B	245.65	243.24	241.56	248.05	246.24	238.64	238.34	236.14	234.12	240.64	238.29	234.16
S$_3$A$_3$	3 L + B	230.84	228.64	227.85	232.68	230.45	229.15	227.84	224.32	225.15	229.36	228.14	227.16
	2 L + B	240.34	238.62	236.54	241.52	239.64	233.46	234.28	236.28	233.46	238.26	236.58	234.12
	1 L + B	242.86	239.06	237.64	239.64	237.68	235.34	236.52	234.86	231.46	241.75	239.24	237.14
Factors		Clone	Time	Leaf standard	Clone	Time	Leaf standard	Clone	Time	Leaf standard	Clone	Time	Leaf standard
CD$_{0.05}$	Factor	0.023	0.029	0.029	0.037	0.045	0.045	0.016	0.020	0.020	0.379	0.464	0.464
	Interaction	0.070			0.111			0.048			1.137		

N.B. L: Leaf; B: Bud

4.4. DPPH free radical scavenging activity

Green tea is known to have higher radical scavenging activity than black tea. In the present investigation, radical scavenging activity of the crude ethanolic sample extracts were measured spectrophotometically using DPPH as a source of free radical. The results were presented in Table 4.

It was observed that average activity (89.35 % inhibition) was highest in case of orthodox green tea manufactured by roasting done for 4 minutes using one leaf and a bud of S3A3. On the other hand, lowest free radical scavenging activity was recorded in case of CGT processed by steaming done for 6 minutes using three leaves and a bud of TV1. In the present investigation, it was observed that loss of polyphenolic compound was more in case of steamed green tea than roasted green tea with increase in steaming time as well as roasting time. Increase in time for deactivation of enzyme was found to cause reduction in antioxidant activity. Introduction of CTC in green tea processing resulted an increased surface area of the leaves that was exposed to the solvent, it facilitated the transfer of bioactive compounds into infusions. The interaction of clone, deactivation time and leaf standard showed a significant change except for CGT processed by steaming done for 2, 4 and 6 minutes as shown by the analysis of variance.

Table 4. Antioxidant activity, in terms of DPPH scavenging (%) of CTC green tea (CGT) and Orthodox green tea (OGT) processed by steaming and roasting method

Clone	Leaf standard	Steaming						Roasting					
		CGT			OGT			CGT			OGT		
		2 min.	4 min.	6 min.	2 min.	4 min.	6 min.	4 min.	5 min.	6 min.	4 min.	5 min.	6 min.
TV 1	3 L + B	74.26	74.18	74.02	76.58	76.24	76.14	75.39	74.24	74.65	78.32	77.25	77.14
	2 L + B	75.68	74.45	74.16	78.64	78.12	76.85	79.12	79.26	77.14	80.35	80.26	78.64
	1 L + B	77.56	76.14	75.58	81.28	81.52	78.25	82.67	82.18	81.54	83.98	82.04	81.18
S_3A_3	3 L + B	79.56	78.12	77.54	74.38	74.56	74.32	76.38	76.12	75.28	79.19	79.02	76.85
	2 L + B	80.32	79.14	78.96	84.65	83.26	83.72	83.72	83.14	82.28	84.47	84.65	82.18
	1 L + B	82.75	81.26	81.52	88.92	88.24	87.18	88.37	88.20	87.54	89.35	88.54	83.16
Factors		Clone	Time	Leaf standard	Clone	Time	Leaf standard	Clone	Time	Leaf standard	Clone	Time	Leaf standard
$CD_{0.05}$	Factor	0.208	0.255	0.255	0.180	0.220	0.220	NS	NS	6.480	0.088	0.107	0.107
	Interaction	0.624			0.539			NS			0.263		

N.B. L: Leaf; B: Bud

4.5 Total flavonoid content

The data pertaining to total Flavonoid content (mg g^{-1} of QE) of CGT and OGT processed by steaming and roasting done for varying periods were presented in Table 5. It was observed that with the increase of leaf age, reduction in flavonoid content was observed in both CGT and Orthodox green OGT. CGT was found to have lesser flavonoid content than OGT. Lowest flavonoid content (16.10 mg g^{-1} of QE) was observed in case of CGT processed from three leaves and a bud of TV1 where steaming was done for 6 minutes. Steaming causes tea leaves softer which increased loss of water soluble components during rolling. However, highest amount of total flavonoid content (22.92 mg g^{-1} of QE) was found in case of OGT using one leaf and a bud of S_3A_3 where roasting done for 4 minutes. It was assumed that high temperature generation during roasting might have decreased flavonoids under prolong deenzyming process. Prolong steaming may also decrease the content of polyphenolic compound. The interaction of clone, deactivation time and leaf standard showed a significant effect except for OGT processed by steaming done for 2, 4 and 6 minutes as shown by the analysis of variance.

Highest flavonoid content was found in the clone S_3A_3 (22.92 mg g^{-1} of QE) than TV1. The highest average antioxidant activity, in terms of DPPH scavenging (%)activity (89.35 % inhibition) was recorded in case of OGT processed by roasting done for 4 minutes using one leaf and a bud of S_3A_3. High antioxidant activity of the clone S_3A_3 might be an indicator of higher flavonoid content in the present study.

Planting material used in China and Japan for green tea processing were reported to have low total polyphenols and accordingly low in astringency and bitterness. It is observed that green tea manufactured in India are known to have higher polyphenol content than those from China which may be due to the use of tea leaves basically used for black tea processing (Harbowy and Balentine, 1997). In a study conducted at Kenya by Kilel (2013) observed that tea clones with low catechin were found to be ideal for green tea processing. It was also reported that in comparison to black tea, green tea contains higher amount of catechin (Hung *et al*., 2010).

The study on comparative performance of the biochemical constituent of OGT and CGT to find out the suitable processing method with improved quality was done by Deka *et al*. (2020) and reported that CGT had significantly high extraction efficiency of bioactive components than orthodox ones which led to a high content of total polyphenol, catechins, theanine and water extract in CGT liquor. The extraction efficiency of total polyphenol, total catechin, theanine and water extract in CGT were 13.3, 7.5, 18.6 and 17.1%, respectively, higher in comparison to OGT. This study provides a new fundamental basis of the economic efficiency of CGT in the light of the higher transfer rate of bioactive compounds from tea to its infusion.

Table 5. Total flavonoid content (mg g^{-1} of QE) of CTC green tea (CGT) and Orthodox green tea (OGT) processed by steaming and roasting method

Clone	Leaf standard	Steaming						Roasting					
		CGT			OGT			CGT			OGT		
		2 min.	4 min.	6 min.	2 min.	4 min.	6 min.	4 min.	5 min.	6 min.	4 min.	5 min.	6 min.
TV 1	3 L + B	16.58	16.24	16.10	18.54	18.44	18.26	17.28	17.82	16.75	18.24	18.04	17.54
	2 L + B	18.62	18.28	18.06	20.75	20.18	20.08	18.24	18.06	17.80	20.15	19.92	18.66
	1 L + B	19.02	18.54	18.12	21.38	21.30	21.04	18.65	18.50	17.86	21.07	21.26	19.80
S_3A_3	3 L + B	18.05	17.84	17.45	19.28	19.35	19.10	17.54	17.20	16.54	19.75	19.44	19.12
	2 L + B	20.65	20.10	19.84	22.35	22.14	19.82	19.92	19.26	18.68	21.86	21.54	21.06
	1 L + B	21.57	21.25	19.86	22.75	22.38	19.94	21.45	21.16	20.18	22.92	22.32	22.10
Factors		Clone	Time	Leaf standard	Clone	Time	Leaf standard	Clone	Time	Leaf standard	Clone	Time	Leaf standard
$CD_{0.05}$	Factor	0.172	0.210	0.212	0.304	0.373	0.370	0.240	0.294	0.294	0.379	0.464	0.464
	Interaction	NS			0.913			NS			NS		

N.B. L: Leaf; B: Bud

5. Discussion

5.1 Moisture content

In normal practice, teas are dried to a moisture content of 3-4% which ensures good keeping qualities, provided that moisture absorption is limited in later stages (Werkhoven, 1988). Geneally to obtain moisture content between 2.5-3%, it is advised to use high drying temperatue for a short duration or low temperature drying for a longer period of time. According to Temple *et al*. (2001), the exposure time had an inverse relationship with temperature. If there is high temperature drying with long duration it will make case hardened tea with burning smell. However, tea with high moisture content cannot be stored for a long period of time. On the other hand removal of excessive moisture from the processed tea is detrimental which causes loss of valuable biomolecules and changes the taste of tea liquor.

`5.2 Ash content

Increased ash content produced in case of roasted green may be caused by temperature treatment and roasting time, causing decrease in water content and other compounds such as antioxidants. Saloko*et al.* (2019) reported that higher the temperature and the longer the roasting process,the higher the level of ground coffee ash. Das *et al.* (2020) reported that orthodox tea manufactured from finer leaf harvest had more ash content than CTC-tea.

5.3 Polyphenol content

Introduction of CTC process disintegrated the tea leaves into granular form which exposed the cell contents to atmospheric oxygen and might be responsible to cause further transformation of polyphenolic compounds. Increase in roasting time was also perhaps responsible for decrease in total polyphenol content in processed green tea. Heat development during roasting was in between 200^{o}C – 230^{o}C. Degradation of polyphenol was more in case of roasting. It may be due to high temperature development during roasting process. Steamed green tea processed from one leaf abud of TV1 was found to have highest amount of polyphenol content. The study done by Deka *et al*. (2020) also supports this finding.

5.4 Antioxidant activity

Progressive increase in deactivation of enzymes present in tea leaves was responsible for reduction in antioxidant activity. These results were in agreement with the findings of Deka et al. (2020) and Deka (2019). Loss of higher amount of polyphenolic compound was also reported in case of steamed green tea than roasted green tea by Neog and Das (2020).

5.5 Flavonoid content

It was observed that with the increase in shoot size from one leaf and a bud to three leaves and a bud, there was reduction in flavonoid content in both CGT and OGT. Sanyal (2016) reported that maximum content of polyphenol was found in bud and it decreased gradually with increase in shoot size. In both steaming and roasting process, there was a reduction in flavonoid content with increase in deactivation time. Steaming causes tea leaves softer which might enhance the loss of water soluble substances during rolling. High temperature generation during roasting may decrease flavonoids under prolong deenzyming process. Prolong steaming may also decrease the content of polyphenolic compound. During prolong roasting, tea polyphenols go through oxidation, hydrolysis, polymerisation and transformation as result there was a reduction in phenolic with progressive increase in temperature (Xu and Chen, 2002).

6. Conclusions

This study provides comparative information on the quality components of OGT and CGT green tea to judge the preferred processing mode with improved quality. This study also provides a new fundamental basis of CGT in the light of secondary metabolites present in it in comparison to orthodox green tea. CGT was found to be bright green in appearance after processing with preferred biochemical constituents. Production of CGT is a new concept in this region and shall benefit the tea producers in future. The bright green infusion, yellowish green liquor colour is encouraging and there is a possibility to introduce granular form of green tea into the market preferably in tea bags. Considering the demand for green tea in recent years, CTC green tea is a new addition that is going to cater to the need of tea lovers in a vastly changing market scenario.

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