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Research Article

Screening for Active Components in Seventeen Marketed Brands of Black Tea of Bangladesh

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Abstract: An initial investigation in seventeen marketed brands of black tea of Bangladesh (*viz;* Seylon, Tetley, Duncan, National, Fresh, Teer, Finlay, Starship, Ispahani, Cosmo, Magnolia, Danish, Shaw Wallace, Pusti, Kazi & Kazi, HRC and Lipton Taaza tea) randomly collected from the local supermarkets was carried out for the variation of qualitative status. The experiment was done in 2016, 2017 and 2018 for determining the active components [caffeine (CAF), total polyphenol (TP), theaflavin (TF), thearubigin (TR), theabrownin (TB), highly polymerized substances (HPS), total liquor colour (TLC), colour index (CI), briskness index (BI) and antioxidant activity (AA)]. All the studied quality parameters were found to vary significantly ($P<0.05$) with the marketed brands of tea. The average values of CAF, TP, TF, TR, TB and HPS in Seventeen marketed brands were determined to be 4.17%, 22.45%, 1.40%, 14.05%, 7.04% and 5.25% respectively. Whilst the average values of TLC, CI, BI and AA in the seventeen marketed brands of tea were estimated to be 4.00; 7.29; 25.28 and 86.77% respectively. The present study concludes that in relation to total active components so far studied, Lipton Taaza tea was regarded as the best one among the seventeen marketed brands of black tea of Bangladesh and all the studied brands of black tea were found to be graded in the order of Lipton Taaza> National> Kazi & Kazi> Cosmo> Duncan> Finlay> Ispahani> Shaw Wallace> Magnolia> Seylon> HRC> Tetley> Teer> Pusti> Fresh> Danish> Starship. The sequence of active components in all the studied brands of tea followed the sequence of price. The market price of all the studied brands of tea was found to be changed positively with the qualitative status.

Keywords: Screening, Active components, Brands, Tea, Bangladesh.

INTRODUCTION

Tea stands as the second most consumed non-alcoholic beverage around the world (Sharangi *et al*., 2014). Tea is consumed throughout the world for its unique taste, briskness and flavour. It is cultivated commercially for use both as a beverage and medicinal purposes (Tanmoy and Bhagat, 2010). For thousands of years, people have used tea as a long-term beverage in long-term drinking without any toxicity or allergies, which reveals that a variety of biochemical substances, such as polyphenolic catechins and methyl xanthine caffeine are safe to humans. As a beverage, tea is the oldest, most popular non-alcoholic drink globally (Chen *et al*., 2003; Gulati *et al*., 2003; Yanagimoto *et al*., 2003; Seenivasan *et al*., 2008; Gebretsadik and Bhagwan, 2010) after water (Wheeler and Wheeler, 2004; Thangapazham *et al*., 2007; Fwu-Ming and Hong-Wong, 2008; Zerabruk *et al*., 2010).

The quality of tea involves parameters such as color, appearance, flavors, and taste. Caffeine is an important factor for quality evaluation (Yao *et al*., 2006) in the way it indicates briskness and other taste properties (Dev Choudhury *et al*., 1991). Although tea contains more caffeine than coffee; a typical serving contains much less, as tea is normally brewed much weaker. Besides strength of the brew, growing conditions, processing techniques and other variables also affect caffeine content. Caffeine or 1,3,5 trimethylexanthenes ($C_8H_{10}O_2N_4$) is an alkaloid. Caffeine is a pharmacologically active substance and depending on the dose, can be a mild central nervous system stimulant. It imparts bitterness and also acts as a flavour constituent (Leo, 1992). Tea leaves contain 3% caffeine by weight, although this can range from 1.4% to 4.5%.

The polyphenols constitute the most interesting group of tea leaf components and exhibit potent antioxidant activity *in vitro* and *in vivo* (Wu *et al*., 2000). Tea has been considered a medicine and a healthful beverage since ancient times, but recently it has received a great deal of attention because tea polyphenols are strong antioxidants. Tea leaves contain 10–30% of dry weight of polyphenols,including catechins, flavonols, flavanones, phenolic acids, glycosides and the aglycones of plant pigments (Pan *et*

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al., 2003). Polyphenols are the active components responsible for the beneficial effects of drinking black tea (Okumura *et al*., 2008). Polyphenols account for 20-35 % (w/w) of the dry tea, thus representing a significant proportion of the tea constituents.

Theaflavins (TF), Thearubigins (TR) are complex phenolic compounds derived from the oxidation of catechins and their gallates during the fermentation stage of black tea processing. Theaflavins (theaflavin, theaflavin-3-gallate, theaflavin-3′-gallate, and theaflavin-3, 3′-digallate) account for 2~ 6% of the solids in brewed black tea. TF contribute the brisk and astringent taste and bright golden color to black tea quality (Yao *et al*., 2006). The golden yellow pigment constitute around 0.5%-2% of dry wt. depending on the type of manufacture of black tea. The attractive color of the tea infusion is due to theaflavins and it emerges as an important quality index of black tea. Theaflavins also provides freshness and aliveness to the infusion, which is highly valued in taster's parlance

Thearubigins (TRs), the orange-brown compounds constituting about 6 to 18% of dry weight are another important group of pigments formed during the processing of black tea but they do not occur in green tea. Thearubigins (characterized by large molecular weights and obscure chemical composition) being the most abundant (Yang *et al*., 2000) in black tea. TR is polymeric proanthocyanidins, and it is reported that some TR are derived from theaflavic acids during fermentation (Obanda *et al*., 2004). They are heterogeneous complexes and are responsible for taste, total color and body of the liquor. They contribute around 35% of the total color and also play a significant role in brown appearance of made tea (Hilton and Ellis, 1972) structure which can dissolve in water and insoluble in ethyl acetate and n butanol or other organic solvents, and show a significant hypocholesterolemic effect (Wang *et al*., 2011; Gong *et al*., 2007). TBs are strongly oxidized and hydrophilic rust-brown products. TB is the main pigment composition and the major component of the quality in Pu-erh tea. TB is an important component in black tea infusion and can determine the color and quality of the black tea (Lianxi, 2005; Xiaochun, 2003).

The thearubigins, on reaction with TF and proteins, form complex highly polymerized substances (HPS).Highly polymerized substances increase the color of the brew. Total liquor color (TLC) is the measure of brightness of the infusion (Muthumani and Kumar, 2006). Higher levels of EGCG and ECG, results in increase caffeine content in green leaf, whereas, the liquor brightness is affected by theaflavins and caffeine contents (Dutta *et al*., 2011). The normal range of briskness index proposed for South Indian black teas is 12.5 to 22.5. But, when it drops below 17.5, the liquors tend to have a harsh taste and when it exceeds 17.5 the liquor gets brisker (Thanaraj and Seshadri, 1990). For better tea, the color index should be between 5 and 11 in order to have the liquor balanced with color and briskness. If the color index value cross 11, then the tea lacks color and when it falls below 5, the liquor will be colored and flat with low briskness (Muthumani and Kumar, 2006).

The major antioxidants in tea are catechins, then theaflavins, thearubigins, oxyaromatic acids, flavonols, such as kaempferol, myricetin, quercetin; flavones, such as apigenin; derivatives of gallic acid, such as tannins, etc. The most powerful antioxidant tea is green tea which is characterized by the presence of large amount of flavan-3-ols known as catechins (-). Epigallocatechin-3-gallate (EGCG) is most abundant catechin in green tea and may occur up to 50% of the catechins by weight. The result of catechins oxidation is the formation of catechins dimers, known as theaflavins. These compounds are responsible for the color and taste and also a key factor in the antioxidant activity. The known in vitro antioxidant properties of catechins and other polyphenolic compounds in tea have led to interest in the potential health benefits of tea consumption (Frei and Higdon, 2003). Numerous epidemiologic studies have addressed the relationships between tea consumption and the incidence of cardiovascular diseases (Stensvold *et al*., 1992). The antioxidant activity of green tea polyphenols and, more recently, the pro-oxidant effects of these compounds, have been suggested as potential mechanisms for cancer prevention (Zheng *et al*., 1996; Imai *et al*., 1997). The effect of black tea consumption, with and without milk, on the plasma antioxidant activity in humans produces a significant increase in plasma antioxidant activity reaching maximal levels at about 60 min (Henning *et al*., 2004).

So far the literature review is concerned, only few experimental works (Karim *et al*., 2000; Alam and Chowdhury, 2007; Alam *et al*., 2015) on the comparative evaluation of caffeine, polyphenols and antioxidant activity of marketed brands of black tea of Bangladesh have yet been done. But a number of tea companies have been marketing a number of their products under different trade names and commercial values. Now the question arises in mind of users whether the quality and commercial value of these products are correlated with each other for their name and fame. With this view in mind a laboratory analyses was undertaken to screen out the comparative status of biochemically active components of seventeen marketed brands of black tea of Bangladesh.

MATERIALS AND METHODS

Collection of Commercial Tea Samples

Seventeen different commercial brands of black Tea (produced in Bangladesh) namely Seylon tea, Tetley tea, Duncan tea, National tea, Fresh tea, Teer tea, Finlay Premium tea, Starship tea, Ispahani tea, Cosmo tea, Magnolia tea, Danish tea, Shaw Wallace tea, Pusti

tea, Kazi & Kazi tea, HRC tea and Lipton Taaza tea were collected from Bangladesh Tea Expo 2017, Dhaka, Chittagong Finlay House, Shaw Wallace trade centre, Rashid Building, Agrabad, Chittagong, various city super shop of Chittagong city respectively. All the commercial brands of tea were mentioned in the present study as "marketed brands of tea".

Laboratory Work

Analytical preparation: All the glassware's were soaked overnight with chromic acid solution and washed thoroughly with water and detergent, then rinsed with deionized water before use. The chemicals and reagents used in this study were of high quality. The tea samples were kept at room temperature throughout the analyses.

Determination of Caffeine

Tea samples were analyzed for Caffeine determination following the method reported by (Wanyika *et al*., 2010).

Calibration standards: Caffeine stock solution (1000 ppm) was prepared by dissolving 100.00 mg of pure caffeine in 100ml of distilled water. 0.10, 20, 40, 60 and 80 ppm caffeine working solution were prepared serial dilution of the stock in 25ml volumetric flasks with addition of 1.0 ml hydrochloric acid and tripping to the mark with distilled water.

Sample preparation and analytic determination: 0.25 g sample were accurately weighed and dissolved in water and made to the net volume of 20 ml with distilled water as sample solution. 20 ml sample solution were pipetted to 250 ml flask and 10 ml of 0.01 mol/l hydrochloric acid, 2 ml basic lead acetate solution were then added and made to the mark with distilled water, shaken up and filtered to clarify. 50 ml filtered solution were pipetted and added to 100 ml flask, 0.2 ml 4.5 mol Sulphuric acid were added and again made to the net volume with distilled water, shaken up and filtered. The absorbance of the working standards and samples were measured by using a UV-visible spectrophotometer (Shimadzu UV-160A PC, *Shimadzu* Corporation, Kyoto, Japan) at 274 nm using 10 mm quartz quvette. The caffeine levels of the samples were calculated from the regression equation of the best line of fit of the standards.

Table 1: Price list of seventeen marketed brands of black tea of Bangladesh along with manufacturing and expiry date.

Brand Name	Collected from	Manufacturing Date	Expiry Date	Weight (g)	MRP Tk	MRP Tk/kg
Seylon Gold Tea	Super market	22/02/2017	21/02/2019	10	5	500
Tetley Premium Leaf Tea	Super market	26/10/2016	26/10/2018	200	85	425
Duncan's Tea	Tea Expo'17	23/12/2016	23/12/2018	100	50	500
National Tea	Tea Expo'17	08/01/2017	08/01/2018	10	5	500
Fresh Premium Tea	Super market	27/04/2016	26/04/2018	200	75	375
Teer Tea	Super market	21/05/2016	21/05/2018	50	18	320
Finlay premium Tea	Finlay House	18.11.2016	17.11.2018	500	220	440
Star Ship Special Tea	Super market	17/04/2016	16/04/2018	500	158	316
Ispahani Zareen Tea	Super market	27/03/2016	27/02/2018	200	88	440
Cosmo Tea	Tea Expo'17	12/07/2016	12/07/2018	50	30	600
Magnolia Tea	Tea Expo'17	15/05/2016	06/02/2017	10	5	500
Danish BOP Tea	Super market	29/12/2015	30/12/2017	500	149	298
Shaw Wallace Super Clone	SW Trade Centre	10/01/2017	10/12/2018	200	99	500
Pusti BOP Tea	Super market	04/05/2016	03/05/2018	500	149	298
Kazi & Kazi	Super market	23/11/2016	22/05/2018	200	130	650
HRC Premium Tea	Tea Expo'17	15/02 2017	15/01/2019	500	173	346
Lipton Taaza	Super market	03/04/2017	02/04/2019	200	85	425

Determination of Polyphenol Contents in Tea Sample

The method was based on that of Roberts (1962) and the Handbook of the Chinese National Centre of Tea Quality Control and Inspection (CNC, 1991) with modification from the recent work of some researchers (Yao *et al*., 1992; Harbowy and Balentine, 1997; Muralidharan, 1997). Details of the method are as follows:

Preparation of tea solution: 200 ml boiling water was added to 2 g of leaf tea or 1 teabag in a 250 ml conical flask and stirred by a magnetic bar on a heated (~90 °C) hot plate for 10 minutes. After filtration, the tea solution was allowed to cool down to room temperature and then made up to 250 ml with distilled water.

Tartrate solution: 1 g $FeSO_4$ and 5 g $KNaC_4H_4O_6$ were dissolved in distilled water and made up to 1000 ml.

Buffer solution: 23.377 g Na_2HPO_4 was dissolved in distilled water to 1000 mL. 9.078 g KH_2PO_4 was dissolved in distilled water to 1000 mL. 85 % (v/v) Na_2HPO_4 solution and 15 % (v/v) KH_2PO_4 solution were mixed as the buffer solution.

Measurement:

1 ml tea solution, 4 ml water and 5 ml tartrate solution were added in a volumetric flask. The buffer was added to make up the mixture to 25 ml. The mixture was measured using a UV-visible spectrophotometer (Shimadzu UV-160A PC, *Shimadzu* Corporation, Kyoto, Japan) at 540 nm.

Calculation:

Total polyphenols were calculated as follows:

Polyphenols (%) = (3.914 E / 1000) × (V_0 / V_1 / W) × 100

Where

E is the reading of the spectrophotometer; V_0 is the total volume of the tea solution (250 mL); V_1 is the volume used for the measurement (1 mL), and W is the dry weight of the tea sample.

Estimation of Theaflavin, Thearubigin, Highly Polysmerised Substances, Total Liquor Color, Briskness Index and Colour Index

Black tea samples were analyzed for TF, TR, HPS and Total Liquor Colour (TLC) by following the method reported by Thanaraj and Seshadri (1990). The briskness and colour indices were worked out as suggested by Ramaswamy (1986), [briskness index (BI) = (TFs x 100)/(TF + Caffeine) and colour index (CI) = (TFs x 100)/(TR + HPS)].

Determination of Theabrownin (TB)

Theabrownin content was determined by the method described by Caffin *et al*. (2004).

Extraction: 3 g of leaf tea or 2 tea bags were added to 125 ml boiling water in a 200 ml conical flask and stirred by a magnetic bar on a heated (~90°C) magnetic stirrer for 10 minutes. After filtration, the tea solution was allowed to cool down to room temperature.

Eb:

15 ml tea was mixed with 15 ml η-butanol and shaken for 3 min. 2 ml of the aqueous layer was added with 2 ml saturated oxalic acid, 6 ml distilled water, and 95 % ethanol to 25 ml.

Measurement:

The absorbency of the solution was measured with the UV-visible spectrophotometer (Shimadzu UV-160A PC, *Shimadzu* Corporation, Kyoto, Japan) at 380 nm with 95 % ethanol as a blank.

Calculation:

Theabrownin (TB) % = 7.06 x 2Eb / (1-M)

Eb is the corresponding readings from the spectrophotometer of the above solutions, while M is the moisture content of the tea sample. If the sample is not 3g, the calculations should be multiplied by 3 and then divided by the practical weight of sample analyzed because this empirical formula was originated from a 3g basis. The percentage of each compound was calculated on a dry weight basis.

Analysis of Antioxidant Activity of Tea Sample

The radical scavenging activity of the tea extracts from leaf obtained from each zone was determined by the 2, 2-diphenyl-2-picrylhydrazyl (DPPH) radical using a modified method of Nadiah and Uthumporn (2015). The assay is based on the measurement of the scavenging ability of antioxidants towards the stable DPPH radical [46]. Details of the method used as follows:

Sample preparation: In order to perform extraction, the samples (1g) were infused in 100 ml of (a) distilled water at 100°C and (b) aqueous ethanol at 50% (v/v). After the 5 minutes extraction process, the infusions were filtered through a tea strainer. The filtrates collected from the extraction process are placed in reagent bottles and covered with aluminum foil to avoid light exposure. The extracts were stored at the temperature of 4ºC for further analysis. Each of the extraction were done in a triplicate terms (n=3).

Determination of DPPH radical activity assay: The capacity of the extract to scavenge the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical activity assay was performed according to the procedure reported by Sanchez-Moreno *et al.* (1998). DPPH reagent was prepared by dissolving 5.9 mg of DPPH powder in 100 ml of methanol, where the mixture was shaken vigorously to ensure that the methanol blended with DPPH powder successfully. After the aforementioned steps, about 0.3 ml of extract solution will be added with 2 ml of DPPH reagent, and subsequently stirred well and kept in a dark environment for 30 minutes. The absorbance of the mixture was measured at 515 nm by using a UV-visible spectrophotometer (Shimadzu UV-160A PC, *Shimadzu* Corporation, Kyoto, Japan). The DPPH reagent without the additional extract solution and ethanol were used as the control. The scavenging activity was calculated using below equation (Sanchez-Moreno *et al*., 1998).

Calculation:

Scavenging activity (%) =1-absorbance sample/absorbance control x 100

STATISTICAL ANALYSIS

All measurements were carried out in triplicate forms. Results of the parameter determined were expressed as a mean of the triplicate determination. The data were analyzed using the one-way analysis of variance (ANOVA) tool under the Statistical Package Social Science (SPSS) 16.0 software. The ANOVA and Duncan's Multiple Range test (DMRT) were completed to compare the mean values and standard deviation among the samples.

RESULTS

Caffeine:

It is apparent from the result that all the studied parametres varied significantly ($P < 0.05$) with the studied brands. The highest amount of caffeine was found to be 4.96% (Cosmo tea) and the lowest amount was found to be 3.16% (Fresh tea). The mean value of the caffeine content among the studied brand was estimated as 4.17%. In respect to caffeine, all the studied brands showed the following sequence as Cosmo > National > Lipton Taaza > Finlay > Duncan > Ispahani > Shaw Wallace > Magnolia > Kazi & Kazi > Seylon > Teer > HRC > Pusti > Danish > Tetley > Starship > Fresh (Table 2). Caffeine content of the studied brands of tea was found to be positive significantly ($P < 0.05$) correlated with TP, TF, TR, TB, HPS, TLC, BI and AA contents (Table 4). The result is comparable with the findings of Cloughley, 1981; Chaudhury, 1990; Chowdhury and Alam, 2001; Alam and Chowdhury, 2007 and Alam *et al.*, 2011.

Caffeine content was determined as 2.2% - 2.8% in the Black tea purchased from the supermarkets of Great Britain (Yashin *et al.*, 2015; Khokhar and Magnusdottir, 2002). Caffeine status of Wissotzky early grey tea, Twinings English breakfast tea, Bigelow Darjeling tea and Lipton tea obtained from the supermarkets of the U.S.A were detected to be 2.71%, 4.54%, 5.51% and 3.62% respectively (Henning *et al.*, 2003). In Chinese Fujian black tea, caffeine content was estimated to be 4.3% (Zuo *et al.*, 2002). Caffeine status of the present experiment is also analogous to these research findings.

Cabrera *et al.* (2003) reported that caffeine content was found to be 3.83%, 4.74%, 4.15%, 6.18%, 6.74% and 4.5% in Sencha tea (Japan), Assam tea (India), Keemun tea (China), Ceylan tea (Sri lanka), English breakfast tea (Sri lanka) and Darjeeling tea (India) respectively. Caffeine content ranged from 2.34%-4.33% in the ten popular commercial tea brands collected from different cities of Pakistan (Adnan *et al.*, 2013). In Chinese marketed black tea, caffeine content was reported to be 8.92% (Xu *et al*., 2011). Caffeine content of black tea purchased from the supermarket of Penang, Malaysia was detected to be 4.19 % (Nadiah and Uthumporn, 2015). These conclusions are in full agreement with the results of present research.

A study focusing on the content of catechin was determined by HPLC in 45 tea grades and the amount of caffeine was detected to be 7.73, 7.68, 6.38, 16.03 and 7.70% in 15 Chinese green tea, 13 Japanese green tea, 9 Chinese and Taiwanese oolong tea, 1 Chinese black tea (85% fermented) and 7 Chinese pu-erh tea respectively (Lin *et al.*, 1998). Caffeine content was determined to be 2.68, 2.30, 7.44 and 2.16% in Japanese Meifoo green tea, Shanghai green tea, Fujian pe-erh tea and Fujian black tea respectively (Zuo *et al.*, 2002). These reports substantiate with the results of present experiment too.

Content of caffeine (brewed up to 5 min.) determined by HPLC-MS was found to be 3.04, 2.07, 2.05, 3.89 and 1.49% in Chinese green tea, Jasmine green tea, Tie Guan Yin oolong tea, Krasno-rozovy black tea and Telley orange pekoe black tea respectively (Wu *et al.*, 2000) which bears a resemblance to the findings of the present study.

The caffeine contents of the present studied brands were found to be reasonably high. According to the Alam and Chowdhury (2007), the mean values of the caffeine content of Bangladesh tea were estimated to be 4.36%, 3.35% and 2.27% in increasing, peak and decreasing period respectively and the average value was 3.32%. Hence, it can be said that Cosmo, National, Lipton Taaza, Finlay, Duncan, Ispahani, Shaw Wallace, Magnolia and Kazi & Kazi tea might have been plucked in increasing plucking period. On the contrary, Seylon, Teer, HRC, Pusti, Danish, Tetley, Starship and Fresh tea might have been plucked in peak plucking period or proper plucking standard as well as manufacturing awareness might not have been maintained. Moreover, among the studied marketed brands of tea, Cosmo tea was recognised as superior in relation to caffeine content.

Total Polyphenol (TP):

Maximum amount of total polyphenol was estimated in Lipton Taaza (28.53%) and minimum amount was estimated in Danish tea (16.07%). The mean value of the total polyphenol content among the studied brands was calculated as 22.45%. In respect to total polyphenol, all the studied brands showed the following sequence as Lipton Taaza > National > Kazi & Kazi > Cosmo > Ispahani > Duncan > Magnolia > Finlay > Shaw Wallace > Seylon > Tetley > HRC > Teer > Pusti > Fresh > Starship > Danish (Table 2). Total polyphenol content of the studied brands of tea was found to be positive significantly ($P < 0.05$) correlated with caffeine, TF, TR, TB, HPS, TLC, AA contents. But there was a negative significant ($P < 0.05$) correlation with CI and BI (Table 4). The result of total polyphenol contents of the marketed brand teas of Bangladesh agree with the investigation of Wang *et al*. (2009) who reported that TP was determined to be 21.97% and 10.31% in green pu-erh tea and black pu-erh tea respectively purchased from the Yunnan region of China. Total polyphenol content of black tea purchased from the supermarket of Penang, Malaysia was detected to be 17.87% (Nadiah and Uthumporn, 2015). Eight brands of tea, which are cultivated and commercially available in Ethiopian market, were analyzed for estimation of their total polyphenols and TP varied from 21.3 ± 0.24 to 31.6 ± 0.31 mg of gallic acid equivalent/g of dry matter (Bizuayehu *et al*., 2016). Both the reports are consistent with the results of present experiment.

Total polyphenol contents ranged from 11.39 to 12.40 ppm GE in five types of commercial black teas obtained from Ho Chi Minh city, Vietnam (Quan *et al*., 2007). Total polyphenol content was determined as 8.05% - 13.49% in the Black tea purchased from the supermarkets of Great Britain (Yashin *et al*., 2015; Khokhar and Magnusdottir, 2002). This information is in agreement with the TP status of present study. Total polyphenol content was estimated to be 22.25%, 19.35% and 18.82% in Kenyan black tea-orthodox, Japanese Yadukita green tea and Chinese Hanlu green tea respectively (Yashin *et al*., 2011). Usually, green teas originating from India or Sri Lanka have higher polyphenol contents (30 %) than those from China (20 %) (Harbowy and Balentine, 1997). Both the conclusions are consistent with the TP status of present study.

Total polyphenol contents of the studied brands were found to be reasonably high. According to the Alam and Chowdhury (2007), the mean values of TP content of Bangladesh tea were estimated to be 22.22%, 28.43% and 16.34% in increasing, peak and decreasing period respectively and the average value was 22.33%. Consequently, it can be assumed that Cosmo, National, Lipton Taaza, Finlay, Duncan, Ispahani, Shaw Wallace, Magnolia, Kazi & Kazi, Seylon, HRC and Tetley teas might have been plucked in increasing or peak plucking period and gained the standard TP content reasonable for Bangladesh tea. On the contrary, Teer, Pusti, Danish, Starship and Fresh teas might have been plucked in decreasing plucking period or proper plucking standard as well as manufacturing awareness might not have been maintained. Meanwhile, in considering total polyphenols, Lipton Taaza was ranked as the best tea marketed in Bangladesh so far.

Table 2: Variation of caffeine, TP, TF, TR and TB contents in seventeen marketed brands of black tea of Bangladesh.

Brands	**Caffeine (%)**[†]	**TP (%)**[†]	**TF (%)**[†]	**TR (%)**[†]	**TB (%)**[†]
Seylon	3.95 ±0.19 de	22.37 ±1.10 efg	1.32 ±0.06 bcde	14.38 ±0.89 def	6.63 ±0.45 b
Tetley	3.34 ±0.07 abc	21.59 ±1.05 ef	1.22 ±0.07 ab	12.47 ±0.35 c	7.45 ±0.51 cd
Duncan	4.78 ±0.17 fg	24.08 ±1.15 gh	1.36 ±0.07 bcdef	16.56 ±0.51 h	8.19 ±0.30 ef
National	4.91 ±0.16 g	27.19 ±0.98 ij	1.66 ±0.07 i	15.76 ±0.61 dgh	8.60 ±0.39 f
Fresh	3.16 ±0.08 a	17.18 ±1.04 ab	1.27 ±0.08 abc	13.67 ±0.70 d	5.36 ±0.26 a
Teer	3.84 ±0.11 d	19.56 ±0.92 cd	1.16 ±0.05 a	12.33 ±0.43 c	7.03 ±0.34 bc
Finlay	4.83 ±0.11 fg	23.57 ±0.97 g	1.55 ±0.09 ghi	16.43 ±0.31 h	7.13 ±0.28 bcd
Starship	3.25 ±0.09 ab	16.35 ±0.78 a	1.28 ±0.06 abc	09.78 ±0.52 a	5.40 ±0.40 a
Ispahani	4.76 ±0.07 fg	25.64 ±0.93hi	1.46 ±0.12 efgh	14.43 ±0.47 def	7.37 ±0.36 cd
Cosmo	4.96 ±0.12 g	26.16 ±1.06 i	1.58 ±0.12 hi	15.27 ±0.32 fg	8.27 ±0.40 ef
Magnolia	4.61 ±0.11 f	23.90 ±1.09 gh	1.43 ±0.06 defg	15.18 ±0.34 efg	6.64 ±0.43 b
Danish	3.46 ±0.06 bc	16.07 ±0.70 a	1.30 ±0.05 abcd	10.98 ±0.44 b	5.21 ±0.34 a
Shaw Wallace	4.73 ±0.15 fg	23.26 ±1.12 fg	1.63 ±0.10 i	14.35 ±0.43 de	7.79 ±0.35 de
Pusti	3.56 ±0.08 c	18.53 ±1.12 bc	1.31 ±0.07 bcd	12.13 ±0.36 c	5.34 ±0.24 a
Kazi & Kazi	4.12 ±0.17 e	26.81 ±1.40 ij	1.33 ±0.06 bcde	16.41 ±0.53 h	7.51 ±0.29 cd
HRC	3.78 ±0.14 d	20.89 ±1.20 de	1.39 ±0.07 cdef	12.22 ±0.31 c	7.14 ±0.30 bcd
Lipton Taaza	4.78 ±0.14 fg	28.53 ±1.22 j	1.48 ±0.07 fgh	16.57 ±0.50 h	8.55 ±0.41 f
Mean	4.17 ±0.66	22.45 ±3.89	1.40 ±0.15	14.05 ±2.09	7.04 ±1.14

[†]Means (n=3) in table followed by a common letter are not significantly different (P > 0.05).

Theaflavin (TF):

The highest amount of theaflavin content was determined to be 1.66% in National tea and the lowest amount was determined to be 1.16% in Teer tea. The mean value of the theaflavin content among the studied brands was found to be 1.40%. In considering the theaflavin content, all the tested brands showed the following sequence as National > Shaw Wallace > Cosmo > Finlay > Lipton Taaza > Ispahani > Magnolia > HRC > Duncan > Kazi & Kazi > Seylon > Pusti > Danish > Starship > Fresh > Tetley > Teer (Table 2). Theaflavin content of the studied brands of tea was found to be positive significantly (P < 0.05) correlated with caffeine, TP, TR, TB, HPS, TLC and AA (Table 4). Theaflavin content of the marketed brand teas of Bangladesh was found to be reasonably high. Theaflavin status of Wissotzky early grey tea, Twinings English breakfast tea, Bigelow Darjeeling tea and Lipton tea obtained from the supermarkets of the U.S.A were estimated to be 1.33%, 2.01%, 0.88% and 1.42% respectively (Henning *et al*., 2003) which agrees with the present investigations.

The average TF content of 30 kinds of teabags was 0.81 % and that of 17 black leaf tea samples was 0.75 %. The contents of TR and TB in teabags were about 1 % higher than in leaf teas. Further investigation found that TF content of the teabags had a range from 0.29% to 1.25%, which showed higher variation than leaf teas that had a range from 0.32% to 1.10%. This may suggest that some teas were processed to produce special market varieties, such as Earl Grey, English

breakfast, Prince of Wales, etc. During the processing of these teas, the producer might add some flavorings and additives that resulted in low TF contents (Caffin *et al*., 2004).

TF content was determined to be 1.38%, 0.03% and 0.08% in Kenyan black tea-orthodox, Japanese Yadukita green tea and Chinese Hanlu green tea respectively (Yashin *et al*., 2011). Theaflavin content was estimated to be 0.79%, 1.54%, 1.15%, 1.47%, 1.17% and 2.21% in the marketed teas of Australia, UK, Continental Europe, Middle East, US and India respectively (Caffin *et al*., 2004; Lakenbrink *et al*., 2000; Bhatia, 1960). TF content was detected to be 1.70% in the Ceylon black tea purchased from the supermarkets of Singapore (Yashin *et al*., 2011 and Leung *et al*., 2001). These conclusions are in full agreement with the

Table 3: Variation of HPS, TLC, CI and BI in seventeen marketed brands of black tea of Bangladesh.

Brands	HPS (%)†	TLC†	CI†	BI†
Seylon	4.03 ±0.26 b	3.41 ±0.10 c	7.17 ±0.56 cdefg	25.04 ±1.23 bcd
Tetley	4.69 ±0.29 c	3.27 ±0.10 bc	7.11 ±0.54 cdef	26.75 ±1.36 cde
Duncan	5.24 ±0.24 d	4.52 ±0.09 fg	6.24 ±0.58 ab	22.15 ±1.24 a
National	6.09 ±0.19 gh	4.86 ±0.09 h	7.60 ±0.57 defg	25.27 ±1.15 bcd
Fresh	4.70 ±0.22 c	2.78 ±0.13 a	6.91 ±0.44 bcde	28.67 ±0.91 e
Teer	3.47 ±0.22 a	3.23 ±0.09 b	7.34 ±0.46 cdef	23.20 ±1.17 ab
Finlay	5.90 ±0.18efgh	4.32 ±0.10 de	6.94 ±0.40 bce	24.30 ±1.00 ab
Starship	4.72 ±0.33 c	2.82 ±0.09 a	8.83 ±0.39 h	28.26 ±1.08 e
Ispahani	5.50 ±0.28 de	4.31 ±0.08 de	7.33 ±0.46 cdefg	23.47 ±1.72 ab
Cosmo	5.20 ±0.15 d	4.87 ±0.10 h	7.72 ±0.48 efg	24.16 ±1.04 ab
Magnolia	5.70 ±0.31defg	4.68 ±0.11 g	6.85 ±0.43 bcdg	23.68 ±1.67 ab
Danish	5.28 ±0.30 d	3.32 ±0.09 bc	8.00 ±0.34 g	27.31 ±0.94 de
Shaw Wallace	6.03 ±0.27 fgh	4.59 ±0.09 fg	8.01 ±0.31 g	25.63 ±1.91 bcd
Pusti	5.27 ±0.35 d	4.16 ±0.09 d	7.53 ±0.31 cdefg	26.90 ±1.62 de
Kazi & Kazi	6.32 ±0.28 h	4.26 ±0.08 de	5.85 ±0.37 abc	24.40 ±1.06 abc
HRC	5.52 ±0.20 de	4.25 ±0.11 de	7.84 ±0.36 fg	26.89 ±1.42 de
Lipton Taaza	5.58 ±0.23 def	4.42 ±0.11 ef	6.68 ±0.35	23.64 ±0.92 ab
Mean	5.25 ±0.75	4.00 ±0.70	7.29 ±0.71	25.28 ±1.90

†Means (n=3) in table followed by a common letter are not significantly different (P > 0.05).

TF status of the marketed brand teas of Bangladesh. In considering the theaflavin content, all the tested brands showed reasonably high amount of TF content which is up to the mark of Bangladesh tea standard. Accordingly, National brand tea was found to be superior in context to theaflavin content among the studied marketed brands of tea in Bangladesh.

Thearubigin (TR):

Maximum amount of thearubigin content was estimated to be 16.56% in Duncan tea and minimum was estimated to be 9.78% in Starship tea. The mean value of the thearubigin content among the studied brands was found to be 14.05%. In context to thearubigin content, all the studied brands showed the following sequence as Duncan > Lipton Taza > Finlay > Kazi & Kazi > National > Cosmo > Magnolia > Ispahani > Seylon > Shaw Wallace > Fresh > Tetley > Teer.> HRC > Pusti > Danish > Starship (Table 2). Thearubigin content of the studied brands of tea was found to be positive significantly ($P < 0.05$) correlated with caffeine, TP, TF, TB, HPS, TLC and AA contents but negative significantly ($P < 0.05$) correlated with CI and BI (Table 4). According to Hilton and Ellis (1972) Thearubigin (TR), generally constitutes about 6 to 18% of dry weight formed during the processing of black tea but they do not occur in green tea. Ten popular marketed brand teas of Bangladesh were investigated in 2010 and the result showed that Maximum TR was determined to be 5.675% in Finlay tea and minimum was determined to be 3.383% Kazi &Kazi tea (Alam *et al*., 2011). These remarks are consistent with the findings of the present study.

TR content was determined to be 11.51%, 9.06% and 9.30% in Kenyan black tea-orthodox, Japanese Yadukita green tea and Chinese Hanlu green tea respectively (Yashin *et al*., 2011). Thearubigin content was determined to be 4.31% and 5.88% in green pu-erh tea and black pu-erh tea respectively purchased from the Yunnan region of China (Wang *et al*., 2009). These reports resemble with the TR status of the present experiment. Thearubigin content was detected to be 8.64%, 11.09%, 11.56%, 12.18%, 9.45% and 16.04% in the marketed teas of Australia, UK, Continental Europe, Middle East, US and India respectively (Caffin *et al*., 2004; Lakenbrink *et al*., 2000 and Bhatia, 1960). While working on five popular marketed brands of tea produced in Bangladesh, the TR content was estimated to be ranged from 5.725% to 4.282% (Alam *et al*., 2015). These observations are comparable to the findings of the present experiment.

So far the thearubigin content is concerned, all the tested brands demonstrated reasonably high amount of TR content which covers the level of Bangladesh tea

standard and certainly comparable with the standard of other tea producing countries. Therefore, Present study suggests that Duncan brand tea is superior in respect to thearubigin content among the studied marketed brands of tea in Bangladesh.

Theabrownin (TB):

The highest amount of theabrownin content was found to be 8.60% in National tea and the lowest amount was found to be 5.21% in Danish tea. The mean value of the theabrownin content of the studied brands was calculated to be 7.04%. In respect to theabrownin content, all the studied brands showed the following sequence as National > Lipton Taza > Cosmo > Duncan > Shaw Wallace > Kazi & Kazi > Tetley > Ispahani > HRC > Finlay > Teer.> Magnolia > Seylon > Starship > Fresh > Pusti > Danish (Table 2). Theabrownin content of the studied brands of tea was found to be positive significantly ($P < 0.05$) correlated with caffeine, TP, TF, TR, TLC and AA contents but negative significantly ($P < 0.05$) correlated with BI (Table 4). Theabrownin content was found to be 5.22%, 7.94% and 3.53% in the Srilankan, Chinese and Australian green teas Purchased from the supermarkets of Australia (Caffin *et al*., 2004).

Theabrownin content was determined to be 2.85% and 9.73% in green pu-erh tea and black pu-erh tea respectively purchased from the Yunnan region of China (Wang *et al*., 2009) which resembles with the findings of the present experiment. Caffin *et al*. (2004) reported that the theabrownin contents ranged from 7.61% to 11.40% in black teabag of Australia with an average of 9.77% which is in full agreement with the findings of present study. The status of theabrownin content determined in all the studied brands is convincingly high and comparable with the standard of other countries. Hence, the Present study puts forward the idea that National brand tea is advanced in relation to theabrownin content among the studied marketed brands of tea in Bangladesh.

Highly Polymerized Substances (HPS):

The highest amount of HPS was determined to be 6.32% in Kazi & Kazi tea and the lowest amount was found to be 3.47% in Teer tea. The mean value of HPS of the studied brands was found to be 5.25%. In case of HPS, all the studied brands showed the following sequence as Kazi & Kazi > National > Finlay > Shaw Wallace > Magnolia > Lipton Taza > Ispahani > HRC > Danish > Pusti > Duncan > Cosmo > Starship > Fresh > Tetley > Seylon > Teer (Table 3). HPS of the studied brands of tea was found to be positive significantly ($P < 0.05$) correlated with caffeine, TP, TF, TR, TLC and AA contents (Table 4). Literature on the HPS status of marketed teas of Bangladesh as well as world tea is very sparse. However, Alam *et al*. (2011) studied on ten marketed brand teas of Bangladesh and found maximum HPS in Finlay tea (4.830%) and minimum in Fresh tea (1.924%) which is consistent with the findings of the present study.

The present investigation corroborates with the annotations of Someswararao *et al.* (2013) who reported that HPS content ranged from10-22% in Indian black tea. While working on five popular marketed brands of tea produced in Bangladesh, Alam *et al*. (2015) estimated the HPS content ranging from 6.253% to 4.121% which bears a close similitude with the results of the present experiment.

In conclusion, taking into consideration of the highly polymerised substances, all the studied brands gave us an idea about reasonably high amount of HPS content which covers the level of Bangladesh tea standard and unquestionably comparable with the benchmark of other tea producing countries. Therefore, Present study suggests that Kazi & Kazi brand tea is superior in relation to HPS among the studied marketed brands of tea in Bangladesh.

Total Liquor Colour (TLC):

The highest amount of TLC was estimated to be 4.87 in Cosmo tea and the lowest amount was estimated to be 2.78 in Fresh tea. The mean value of TLC of the studied brands was found to be 4.00. In case of TLC, all the studied brands showed the following sequence as Cosmo > National > Magnolia > Shaw Wallace > Duncan > Lipton Taza > Finlay Ispahani > Kazi & Kazi > HRC > Pusti > Seylon > Danish > Tetley > Teer >Starship > Fresh (Table 3). TLC of the studied brands of tea was found to be positive significantly ($P < 0.05$) correlated with caffeine, TP, TF, TR, TB and AA contents but negative significantly ($P < 0.05$) correlated with BI (Table 4). The status of total liquor colour in the seventeen marketed brand teas of Bangladesh substantiates with the findings of Alam *et al*. (2011) who studied on ten marketed brand teas of Bangladesh and found maximum TLC in Finlay tea (2.30) and minimum in Kazi &Kazi (1.56). Someswararao *et al.* (2013) reported that total liquor colour in Indian black tea was found to have been ranging from 3.89% to 5.7% which is consistent with the results of the present experiment.

While working on five popular marketed brands of tea produced in Bangladesh, Alam *et al*. (2015) estimated the TLC content ranging from 2.56 to 3.44. This remark is in full agreement with the TLC status of the present study. The standing of TLC in the Present study is a similar to those above mentioned research results. In conclusion, it is clear from the results that total liquor colour of the marketed brand teas of Bangladesh is better comparable with the TLC standard of other countries and Cosmo tea was considered as the best one in Bangladesh while TLC content is concerned.

Colour Index (CI):

Maximum amount of CI was determined to be 8.83 in Starship tea and minimum amount was determined to be 5.85 in Kazi & Kazi. The mean value of CI of the studied brands was found to be 7.29. In terms of CI, all the studied brands demonstrated the following sequence as Starship> Shaw Wallace> Danish> HRC> Cosmo> National> Pusti> Teer> Ispahani> Seylon> Tetley> Finlay> Fresh> Magnolia> Lipton Taza> Duncan> Kazi & Kazi (Table 3). Colour index (CI) of the studied brands of tea was found to be positive significantly ($P < 0.05$) correlated with BI content but negative significantly ($P < 0.05$) correlated with TP and TR contents only (Table 4). The status of colour index in the seventeen marketed brand teas of Bangladesh corroborates with the findings of Alam *et al*. (2011) who studied on ten marketed brand teas of Bangladesh and found maximum CI in Kazi & Kazi tea (11.72) and minimum in Ispahani tea (5.91).

While working on five popular marketed brands of black tea produced in Bangladesh, Alam *et al*. (2015) estimated the colour index ranging from 8.75 to 10.94. This remark is in full agreement with the CI status of the present study. In conclusion, it is obvious from the results that colour index of the marketed brand teas of Bangladesh is better comparable with the CI standard of other countries and Starship tea was ranked as the toppest one in Bangladesh while colour index is concerned.

Briskness Index (BI):

Maximum amount of briskness index was determined to be 28.67 in Fresh tea and minimum amount was determined to be 22.15 in Duncan tea. The mean value of BI of the studied brands was calculated to be 25.28. In considering the briskness index, all the studied brands showed the following sequence as Fresh > Starship > Danish > Pusti > HRC > Tetley > Shaw Wallace > National > Seylon > Kazi & Kazi > Finlay > Cosmo > Magnolia > Lipton Taza > Ispahani > Teer.> Duncan (Table 3). Briskness index (BI) of the studied brands of tea was found to be positive significantly ($P < 0.05$) correlated with caffeine and CI contents only but negative significantly ($P < 0.05$) correlated with TP, TR, TB and TLC contents (Table 4). Alam *et al*. (2011) determined briskness index in ten popular marketed brand teas of Bangladesh and the highest BI was found to be 23.51 in Kazi & Kazi tea and the lowest was found to be 14.46 in Ispahani tea which is in full agreement with the results of present experiment. The status of briskness index in seventeen marketed brand teas of Bangladesh substantiates with the observations of Alam *et al*. (2015), who worked on five popular marketed brand teas of Bangladesh and estimated the briskness index ranging from 24.76 to 21.88.

Table 4: Correlation coefficient matrix analysis between different active components of seventeen marketed brands of black tea of Bangladesh.

Caf	TP	TF	TR	TB	HPS	TLC	CI	BI	AA	
-	0.85**	0.82**	0.81**	0.79**	0.53*	0.88**	0.28	0.78**	0.85**	Caf
	-	0.65**	0.86**	0.89**	0.53*	0.79**	-0.51*	-0.72**	0.83**	TP
		-	0.58*	0.59*	0.70**	0.80**	0.09	-0.29	0.63**	TF
			-	0.73**	0.50*	0.70**	-0.74**	-0.71**	0.70**	TR
				-	0.35	0.70**	-0.36	-0.69**	0.81**	TB
					-	0.71**	-0.19	-0.12	0.58*	HPS
						-	-0.25	-0.61**	0.86**	TLC
							-	0.55*	-0.38	CI
								-	-0.75**	BI
									-	AA

**Significant at p<0.05, **Significant at p<0.01*

Result of a research in Indonesia showed that brewing period arrangement for 12 minutes initiated brewing for 3 minutes has the highest of briskness index, i.e. 22.71 with 0.29% theaflavin content. In contrast, brewing period arrangement technique for 3 minutes initiated by brewing period 12 and 6 minutes respectively were liquored with the lowest briskness index i.e. 13.73 with 0.10% theaflavin content which concluded that black tea could be brewed until 3 times (Rohdiana and Shabri, 2014). This remark also corroborates with the findings of the present investigation. In fine, in considering the briskness index, all the studied brands demonstrated convincingly high amount of BI which covers the level of Bangladesh tea standard and indubitably analogous to the standard of other tea producing countries. Therefore, Present study recommends that Kazi & Kazi brand tea would be considered as superior in relation to briskness index among the studied marketed brands of tea in Bangladesh.

Antioxidant Activity (AA):

The highest amount of antioxidant activity (AA) was determined to be 92.52% in Cosmo tea and the lowest amount was determined to be 77.85% in Starship tea. The mean value of AA of the studied brands was calculated to be 86.77%. In concerning the antioxidant activity (AA), all the studied brands showed the following sequence as Cosmo > Magnolia > National > Lipton Taza > Kazi & Kazi > Ispahani >

Duncan > Finlay > Shaw Wallace > HRC > Teer.> Tetley > Danish > Pusti > Seylon > Fresh > Starship (Figure 1). Antioxidant activity (AA) of the studied brands of tea was found to be positive significantly ($P < 0.05$) correlated with caffeine, TP, TF, TR, TB, HPS, TLC and CI contents but negative significantly ($P < 0.05$) correlated with BI only (Table 4). Eight brands of tea, which are cultivated and commercially available in Ethiopian market, were analyzed for estimation of their antioxidant activity by using DPPH radical assays The free radical scavenging activity among the tea brand samples ranged from 28.8 ±1.86 to 80.0 ± 0.63 mg ascorbic acid equivalent/g and the half maximal inhibitory concentration (IC 50%) values varied from 7.3 ±1.35 to 64.0 ±2.81 µg/mL of extract (Bizuayehu *et al*., 2016).

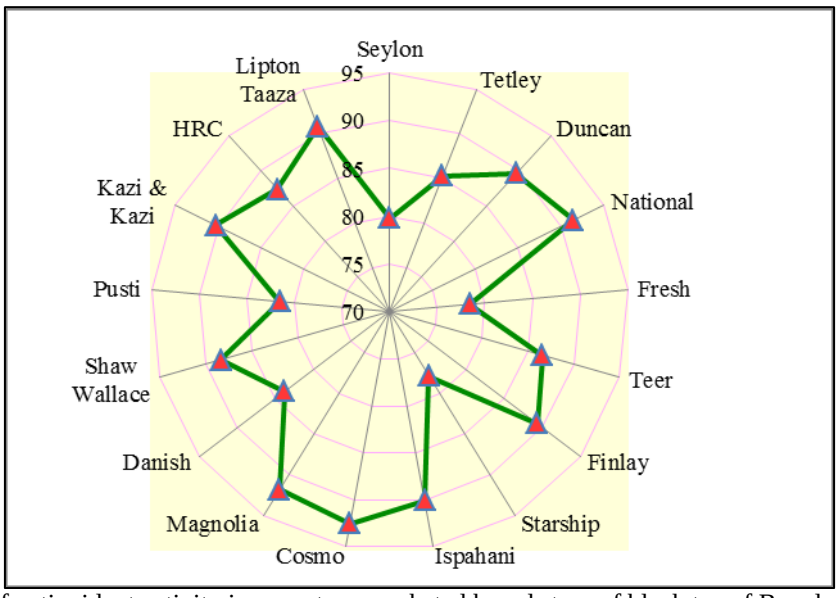

Figure 1: Variation of antioxidant activity in seventeen marketed brands teas of black tea of Bangladesh.

Antioxidant activity ranged from 99 to 191 mg VCE in five types of commercial black teas obtained from Ho Chi Minh city, Vietnam (Quan *et al*., 2007). Three commercial black teas of Brazil were investigated for antioxidant activity where AA ranged from 45.10 to 37.30 IC_{50} (Pereira *et al*., 2014). Antioxidant activity of black tea purchased from the supermarket of Penang, Malaysia was detected to be 76.44% (Nadiah and Uthumporn, 2015). Yashin *et al*. (2011) estimated antioxidant activity of green tea as 171.2, 143.0, 139.60, 126.80, 98.0 and 80.40 CCA mg/g in Alokozay (Dubai, UAE), Lipton (Unilever), Nama Cha (Japan), Merlin (Srilanka), Maitre (France) and Jasmine tea (China) respectively. In conclusion, it is apparent from the results that antioxidant activity of the marketed brand teas of Bangladesh is convincingly high and better comparable with the standard of other tea producing countries of the world. Accordingly, Cosmo tea was ranked as the best tea in Bangladesh so far the antioxidant activity is concerned.

Total Qualitative Status

The results of the total qualitative status of seventeen marketed brand teas of Bangladesh reveal that the highest quantity of total active components (total of caffeine, TP, TF, TR, TB and HPS) was detected to be 65.49% in Lipton Taaza tea and the lowest quantity was detected to be 40.78% in Starship tea and maintained the progression as Lipton Taaza> National> Kazi & Kazi> Cosmo> Duncan> Finlay> Ispahani>Shaw Wallace>Magnolia> Seylon> HRC> Tetley> Teer> Pusti> Fresh> Danish> Starship (Figure 2).

Price of the Marketed Brands:

The market prices of seventeen marketed teas of Bangladesh are shown in Table 5.1. It is evident from the results that the maximum price/kg was observed in Kazi & Kazi tea (650Tk/kg) and the minimum price was observed in Danish tea (298 Tk/kg) and followed the sequence as Kazi & Kazi> Cosmo> Duncan> National> Seylon> Magnolia> Shaw Wallace> Finlay> Ispahani> Lipton Taaza> Tetley> Fresh> HRC> Teer> Starship> Pusti> Danish (Figure 3). It is obvious from the result that market price of the studied seventeen marketed brand teas of Bangladesh was almost dependent on the total amount of biochemical composition. The sequence of biochemical composition in all the studied brands of tea followed the sequence of price. This result corroborates with the findings of Alam *et al.* (2018a) and Alam *et al.* (2018b). The market price of all the studied brands of tea was found to be changed positively with the qualitative status. The results also indicate that the higher the biochemical composition in the teas of brand was as the higher the price.

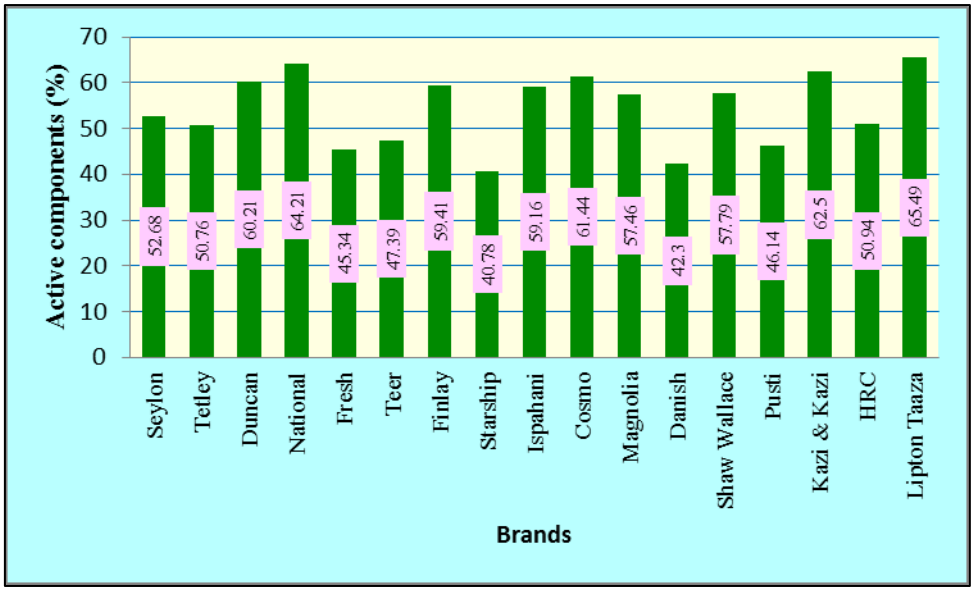

Figure 2: Total active components of seventeen marketed brands of black tea of Bangladesh.

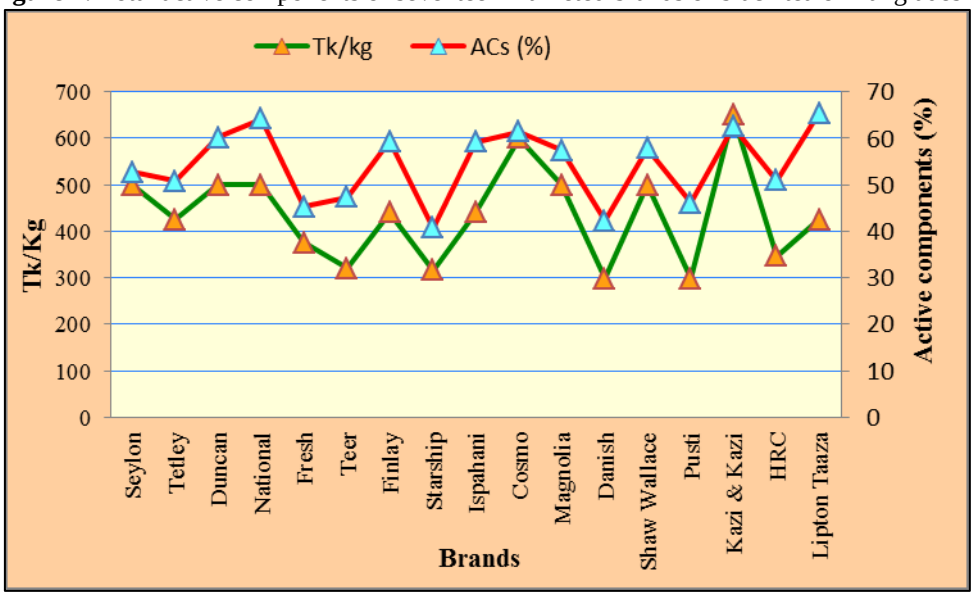

Figure 3: Comparison of qualitative status and market price of seventeen marketed brands of black tea of Bangladesh

CONCLUSION

The present study concludes that all the studied parameters of the seventeen marketed brands of black tea of Bangladesh varied significantly with brands. The quantity of each active component was found to be reasonably high and better comparable with the qualitative status of black tea produced as well as marketed in other countries. The sequence of biochemical composition in all the studied brands of tea followed the sequence of price. The market price of all the studied brands of tea was found to be changed positively with the qualitative status. The present experiment further concludes that in relation to active components (sum of caffeine, total polyphenol, theaflavin, thearubigin, theabrownin and highly polymerized substances), Lipton Taaza was found to be the most excellent among the seventeen marketed brands of black tea of Bangladesh and all the marketed brand teas were observed to be ranked as Lipton Taaza> National> Kazi & Kazi> Cosmo> Duncan> Finlay> Ispahani> Shaw Wallace> Magnolia> Seylon> HRC> Tetley> Teer> Pusti> Fresh> Danish> Starship.

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