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Qualitative and quantitative evaluation for caffeine, phenolic compounds and nutrient elements in six marketed brands of Kazi and Kazi tea produced in Bangladesh

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Abstract
Six marketed brands of Kazi and Kazi tea produced in Bangladesh *viz*; Black tea, Ginger tea, Tulsi tea, Green tea, Orthodox black tea and Orthodox green tea were studied before expiry dates for qualitative and quantitative evaluation to screen out their status of caffeine, phenolic compounds [Total Polyphenol (TP), Theaflavin (TF), Thearubigin (TR), Highly Polymerized Substances (HPS), Total Liquor Colour (TLC), Briskness Index (BI) and Colour Index (CI)] and nutrient elements (N, P, K, Ca and Na). All the studied parameters were found to have been varied with brands. The values of caffeine and TP were found to be varied from 2.24% (Orthodox green tea) to 2.65% (Black tea) and 18.84% (Black tea) to 21.88% (Orthodox green tea) respectively. Likewise, the estimated amounts of TF, TR, TLC, CI and BI were determined to be the highest in Black tea but maximum HPS was in Orthodox green tea whereas the lowest TF, TLC and CI were determined in Orthodox green tea. On the other hand TR, and BI were detected to be minimum in Ginger tea and HPS was detected to be minimum in Black tea. On the contrary, the total amount of studied nutrient contents (N, P, K, Ca and Na) was estimated to be the highest in Orthodox black tea (9.99%) and the lowest in Ginger tea (7.55%). The present study concludes that the Orthodox green tea is superior over the other brands in relation to total qualitative status and consequently, all the studied brands of Kazi and Kazi tea may be ranked as Orthodox green tea>Green tea>Orthodox black tea>Ginger tea>Black tea>Tulsi tea.

Keywords: Evaluation, caffeine, phenolic compounds, nutrient elements, brands, Kazi and Kazi tea, Bangladesh

Introduction
Tea refers to the agricultural products of the leaves, leaf buds and internodes of the Camellia sinensis plant. It has been consumed as a beverage for almost 2,000 years starting in China (Atomssa and Gholap, 2011) [1]. It is the most widely consumed beverage after water (Alan and Iris, 2004) [2]. Teas from many areas may be blended. The aim is to obtain better taste, higher price or both, as a more expensive, better tasting tea may cover the inferior taste of cheaper varieties. There are two major kinds of tea, black tea and green tea. Both contain caffeine (1 to 5) % of its dry weight (Amro *et al*., 2006) [3] depending on type, brand (Bennett and Bonnie, 2001) [4] and brewing method (Hicks *et al*., 1996) [5]. This is why the reported values in the literature are so variable.

Caffeine belongs to a family of naturally occurring components known as xanthines. The xanthines which come from plants are possibly the oldest known stimulants. Caffeine is the most powerful xanthine, in its ability to increase alertness, put off sleep and to improve attention in study (Bolton and Null, 1981) [6], caffeine is a vasodilator (relaxes the blood vessels) as well as a diuretic (increase urination). On the other hand, sever restlessness and excitement, leading to mild delirium, muscular tension and twisting and cardiovascular disturbances such as tachycardia, are negative effects of caffeine at large doses. The spinal cord is stimulated at higher doses, convulsions and death may result (Bolton and Null, 1981) [6]. Caffeine is regarded as an important constituent of tea, bestowing mood and cognitive-enhancing properties (Chow and Kramer, 1990) [7].

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 al*., 2003) [8]. Tea polyphenols behaves as natural antioxidant (Tanizawa *et al*., 2014) [9] and some studies suggest that regular consumption of tea can reduce the risk of developing a variety of cancers, namely colon, pancreatic, and stomach cancers (Steiwan *et al*., 2001; Wang *et al*., 2000) [10, 11]. Polyphenols are the active components responsible for the beneficial effects of drinking green tea (Okumura *et al*., 2008) [12].

A large number of polyphenol derivatives have been identified in various types of green (non-fermented), oolong (semi-fermented) and black (fully-fermented by oxidizing enzyme) teas (Peterson *et al*., 2005) [13].

Polyphenols occurring in black tea usually consist of residual green tea polyphenols such as catechins (Bailey *et al*., 1990; Ding *et al*., 1992) [14, 15], flavonols (Bailey *et al*., 1990; McDowell *et al*., 1990) [14, 16] and oxidation products of green tea polyphenols such as theaflavins and thearubigins. Most of the catechins and their gallates undergo known enzymatic oxidation to form more polymeric polyphenols that are characteristic of black tea, namely theaflavins and thearubigins. Theaflavins are known as fermentation products and provide a bright, yellowish appearance to the beverage and have long been positively correlated with the quality and market value of black tea (Roberts, 1958a; Roberts, 1958b; Roberts, 1962) [17-19]. Theaflavin with a formula $C_{29}H_{24}O_{12}$ (Brown *et al*., 1966) [20] may contain 3.5 moles of water in the crystallization (Takino *et al*., 1965) [21]. The content of total theaflavins in black tea does not usually exceed 2% and can be as low as 0.3% (Balentine *et al*., 1997) [22], whereas Graham (1992) [23] reported that theaflavins ranged 1.5-2.5% in the dry leaf.

Further oxidation of theaflavins produces a group of brown pigments called thearubigins (Roberts, 1958a; Roberts, 1962) [17, 19]. The content of theaflavins is far less than that of thearubigins in black tea (6 to 18% of dry weight), but theaflavins are of primary importance to tea quality, since they impart the specific bright and vivid colour to the liquor; and further, the ratio of theaflavins to thearubigins has been found to be responsible for the strength of the tea liquor (Bolton and Null, 1981) [6]. The thearubigins, on reaction with TF and proteins, form complex highly polymerized substances (HPS). Highly polymerized substances increase the colour of the brew. Total liquor colour (TLC) is the measure of brightness of the infusion (Muthumani and Kumar, 2006) [24].

The quality of a tea is formed during the growth and development of the tea plant, when the compounds responsible for quality are synthesised (Bokuchava and Skobeleva, 1969) [25]. Good quality teas contain less high molecular weight compounds than those of inferior quality (Bradfield, 1946) [26]. For black tea, a high proportion of extractable polyphenols may indicate a good quality liquor, with astringency and a bright reddish colour. As an aid to judging quality, a finely divided precipitate formed during the cooling of black tea liquor is referred to by tea tasters as the "cream down" of tea (Bradfield, 1946) [26]. This cream consists largely of extractable polyphenols such as theaflavins and thearubigins, and other flavonoids in combination with caffeine. Interactions between caffeine and the polyphenols are primarily responsible for this cream (Collier *et al*., 1972) [27]. The composition of a cream in an Assam tea infusion brewed with a tea/water ratio of 1/40 is: ca 15% theaflavins, 65% thearubigins, 14% caffeine, 3% ash and other compounds (Smoth, 1968) [28].

After years of research, Eden (1976) [29] concluded that the dynamics of the production of theaflavins is the most potent single factor in promoting good quality in tea. In addition, Davies (1983) [30] suggested that the content of theaflavins and the percent of extractable solids in a black tea could be used as objective measures of the tea quality. Patterns or levels of phenolic compounds in black tea liquor have been used as means of predicting price and country of origin (McDowell *et al*., 1991) [31]. A good quality tea possessing brightness, briskness, and good colour and body may possess a ratio of theaflavins: thearubigins of 1:10 (Deb and Ullah, 1968) [32].

So far the literature review is concerned; only a few comparative studies on the qualitative status of marketed brand teas of Bangladesh were done. With this view in mind, in addition to those brands of tea, a laboratory experiment was done to screen out the comparative status of quality parameters viz; caffeine, phenolic compounds (TP, TF, TR, HPS, TLC, BI, CI) as well as nutrient status (N, P, K, Ca and Na) in six marketed brands of Kazi and Kazi tea of Bangladesh.

Materials and Methods

Six marketed brands of Ispahani tea grown in Bangladesh *viz*; Black tea, Ginger tea, Tulsi tea, Green tea, Orthodox black tea and Orthodox green tea were collected from the local market of Chittagong city, Bangladesh at a time.

Determination of caffeine in tea samples

Tea samples were analyzed for Caffeine By the method Reported by Wanyika *et al*., (2010) [33].

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 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 on a UV-visible spectrophotometer (Shimadzu UV-160A PC, Shimadzu Corporation, Kyoto, Japan) at 274 nm using 10 mm quartz cuvette.

Calculation

The caffeine levels of the samples were calculated from the regression equation of the best line of fit of the standards

Determination of Polyphenol in tea samples

Preparation of 1000 ppm tannic acid stock solution

1g tannic acid was taken in a 1000ml volumetric flask. Then, small amount of distilled water was added and shaken well to dissolve tannic acid. Then, the volume was made up to the mark with the addition of distilled water. This solution was used as 1000 ppm stock solution. From 1000ppm stock solution 1ppm, 2ppm, 3ppm, 4ppm & 5ppm solution were prepared.

Procedure

100 mg of tea sample was boiled in a water bath with 100 ml of water for 30 minutes and filtered. 0.2 ml of the sample solution and 5ml of the reagent (100mg of $FeS0_4$. $7H_2O$ and 500mg of Rochelle salt in 100ml of water) were taken in a 25ml volumetric flask and filled to the mark with Sorensen's

phosphate buffer of pH 7.5. Then the absorbance was measured at 540 nm against a blank solution substituting water for the reagent and the amount of polyphenol was determined using the correction factor (cf) obtained from the calibration curve made by using different concentration of tannic acid (Molla, 1981) [34].

Black tea samples were analyzed for TF, TPC, TR, HPS and Total Liquor Colour (TLC) by following the method reported by Thanaraj and Seshadri (1990) [35]. The briskness and colour indices were worked out as suggested by Ramaswamy (1986) [36]. Nutrients (viz. N, P, K, Ca and Na) were extracted with sulfuric-peroxide (H_2SO_4+H_2O_2 digestion mixture and determined by standard method (Jackson, 1973) [37]. Every data was the mean value of three samples (bought one time and split into three samples) and statistical analysis was done using the computer progamme (SPSS). Means were compared using the least significant difference test (LSD) at P>0.05 (Steel *et al*., 1997) [38].

Results and Discussion

The results as presented in Table 1 exhibit that caffeine content of Kazi and Kazi tea was found to vary with brands. The maximum value of caffeine content was found to be 2.65% (Black tea) and the minimum value was found to be 2.24% (Orthodox green tea) and showed the following sequence as Black tea>Orthodox black tea>Tulsi tea>Ginger tea>Green tea>Orthodox green tea. Tea generally contains caffeine at about 1-5% of its dry weight (Balentine, *et al*., 1998) [39]. The average range of caffeine content in Bangladesh tea is 3.3-4.8% (Choudhury, 1990; Chowdhury and Alam, 2001) [40, 41] which is in full agreement with the results of present study.

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) [42]. In Chinese Fujian black tea, caffeine content was estimated to be 4.3% (Zuo *et al*., 2002) [43]. Cabrera *et. al.* (2003) [44] 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 (Srilanka), English breakfast tea (Srilanka) and Darjeeling tea (India) respectively. These conclusions substantiate with the results of present research.

Caffeine content varies with agrotypes, plucking periods and commercial brands. Maximum caffeine content is found in increasing plucking period (April-June) and minimum in decreasing plucking period (October-December) (Alam *et al*., 2011) [45]. It is also reported that caffeine content of Bangladesh tea was found to vary from 3.87% to 4.67%, 2.53% to 3.87% and 1.73% to 2.67% in increasing, peak and decreasing plucking periods respectively (Alam and Chowdhury, 2007) [46]. So it is evident from the result that the caffeine contents of present experiment can be ranked as medium in respect to Bangladesh standard and all the studied brands might have been harvested in between late peak plucking period (July-September) and decreasing plucking period (October-December).

The results as shown in Table 1 also exhibit that total polyphenol (TP), theaflavin (TF), thearubigin (TR), highly polymerized substances (HPS) and total liquor colour (TLC) content were found to be varied with brands of Kazi and Kazi tea. The highest amount of total polyphenol (TP) was estimated to be 21.88% in Orthodox green tea and the lowest was 18.84% in Black tea. Total polyphenol content followed the sequence as Orthodox green tea> Green tea>Ginger tea>Tulsi tea>Orthodox black tea>Black tea. Tea generally contains 15-18% of polyphenol (Cloughly, 1981) [47]. The range of total polyphenol content in Bangladesh tea is 22-31% (Choudhury, 1990; Chowdhury and Alam, 2001) [40, 41]. These findings agree with the TP status of the present experiment.

Table 1: Variation of caffeine, TP, TF, TR and HPS contents (%) in six marketed brands of Kazi and Kazi tea.

Brand	Caffeine	TP	TF	TR	HPS	Total
Black tea	2.65	18.84	0.70	4.32	2.05	28.56
Ginger tea	2.42	20.96	0.60	3.89	2.63	30.50
Tulsi tea	2.48	20.06	0.65	4.21	2.62	30.02
Green tea	2.34	21.55	0.60	4.05	2.12	30.66
Orthodox black tea	2.51	19.48	0.64	4.24	2.54	29.41
Orthodox green tea	2.24	21.88	0.59	3.93	2.71	31.35
LSD at P >0.05	0.25	0.42	0.06	0.19	0.28	0.48

Total polyphenol content of black tea purchased from the supermarket of Penang, Malaysia was detected to be 17.87% (Nadiah and Uthumporn, 2015) [48]. 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) [49]. These conclusions are in agreement with the TP status of present study.

It is also reported that total polyphenol content of Bangladesh tea ranged from 20.79% to 23.57%, 24.60% to 31.54%, 6.58% to 10.74% in increasing, peak and decreasing plucking periods respectively (Alam and Chowdhury, 2007) [46]. Caffeine, TP, TF, TR, HPS and TLC contents fluctuates following climatic variations and decreases after rainy season (Malec, 2006)[50]. So present experiment reveals that total polyphenol content of all the six studied brands are reasonably low and are not comparable with Bangladesh standard. The result also indicates that all the studied brands might have been manufactured from the tea shoots plucked in decreasing plucking period (October-December) or plucking standard might has not been maintained properly. Meanwhile, the high amount of total polyphenol in Ginger tea and Tulsi tea may be due to presence of phenolic substances in the added ginger and tulsi leaves.

Maximum value of TF content was observed to be 0.70% (Black tea) and minimum value was observed to be 0.59% (Orthodox green tea) and showed the following sequence as Black tea>Tulsi tea>Orthodox black tea>Ginger tea>Green tea>Orthodox green tea (Table 1). The content of total theaflavins in black tea does not usually exceed 2% and can be as low as 0.3% (Balentine *et al*., 1997) [51], whereas Graham (1992) [52] reported that theaflavins ranged 1.5-2.5% in the dry leaf which agrees with the results of the present investigation.

Theaflavin contents ranged from 0.96% to 2.072% at a mean value of 1.54% in the black tea of 25 different types of Kenyan tea cultivars (Karori *et al*., 2014) [53]. 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*. 200; Bhatia, 1960) [54-56]. TF content was detected to be 1.70% in the Ceylon black tea purchased from the supermarkets of Singapore (Yashin, *et al*., 2011; Leung *et al*., 2001) [57, 58]. These remarks are consistent with the TF status of the marketed brand teas of Kazi and Kazi.

On the other hand TR content ranged from 3.89% (Ginger tea) to 4.32% (Black tea) and showed the following sequence as Black tea>Orthodox black tea>Tulsi tea>Green tea>Orthodox green tea>Ginger tea (Table 1). According to Hilton and Ellis (1972) [59] 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. Thearubigin content was estimated 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*. 200; Bhatia, 1960) [54-56]. 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) [60]. These observations are comparable to the findings of the present experiment.

The highest amount of HPS content was determined to be 2.71% (Orthodox green tea) and the lowest amount was determined to be 2.05% (Black tea) and showed the following sequence as Orthodox green tea>Ginger tea>Tulsi tea>Orthodox black tea>Green tea>Black tea (Table 1). Literature on the HPS status of marketed teas of Bangladesh as well as world tea is very sparse. However, Alam *et al*. (2011) [45] 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 also corroborates with the annotations of Someswararao *et al*. (2013) [61] who reported that HPS content ranged from10-22% in Indian black tea.

In contrast Black tea contained maximum amount of TLC content (1.87) and Green tea contained minimum amount of TLC (1.44). The values of TLC showed the following sequence as Black tea>Ginger tea>Orthodox black tea>Tulsi tea>Green tea>Orthodox green tea (Fig. 1). The status of total liquor colour in the six marketed brand teas of Kazi and Kazi substantiates with the findings of Alam *et al*. (2011) [45] 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) [61] 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) [60] 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.

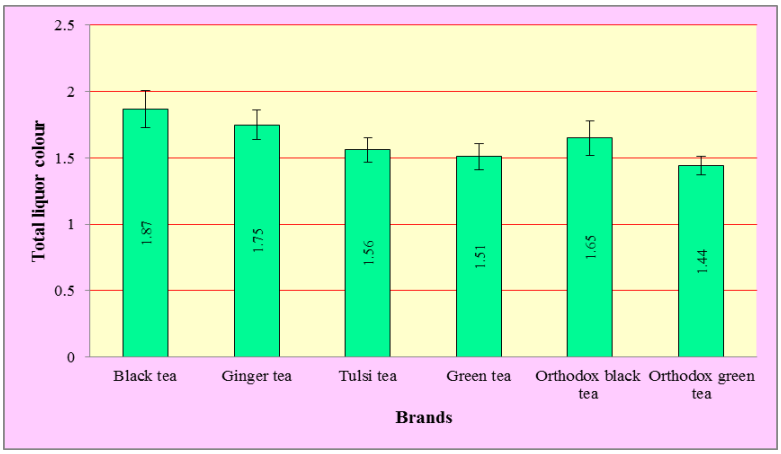

Fig. 1: Total liquor colour status of six marketed brands of Kazi and Kazi tea.

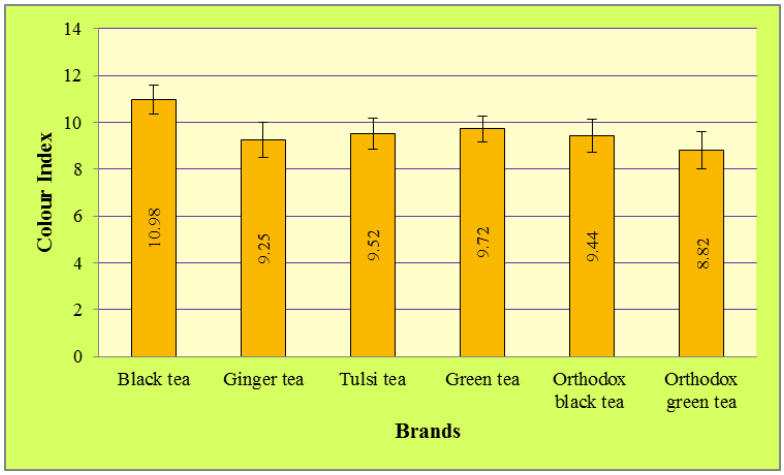

Fig 2: Colour index status of six marketed brands of Kazi and Kazi tea.

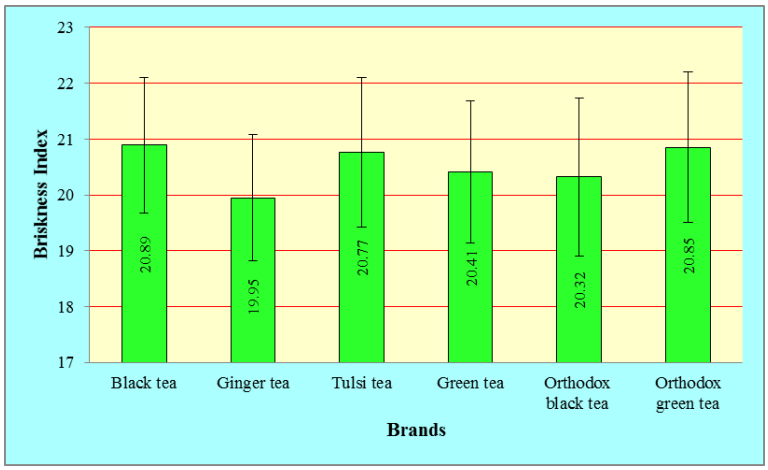

Fig. 3: Briskness index status of six marketed brands of Kazi and Kazi tea.

In case of Bangladesh tea, it is reported that in the tea of two leaves and a bud with third internode the average TF, TR, HPS and TLC contents were determined as 1.035%, 5.798%, 6.821% and 3.350 respectively. But all of these components trends to be decreased downward significantly in the tea of four leaves and a bud with fifth internode whilst the contents were determined as 0.733%, 4.127%, 3.956% and 2.30 respectively (Karim *et al*., 2000) [62]. It is also suggested that plucking standard should be maintained up to two leaves and a bud including third internode for the production of teas having proper caffeine, TP, TF, TR, HPS and TLC contents to optimize the black tea quality (Karim *et al*., 2000) [62].

Therefore, from the results of this experiment, it can be assumed that TF, TR, HPS and TLC contents of all the studied brands of Kazi and Kazi tea were not up to the mark in comparison to Bangladesh standard. Every brand possessed low TF, TR, HPS and TLC contents which were supposed to be obtained from four leaves and a bud with fifth internode and downward plucking. So, all the studied brands might not have maintained plucking standard as well as manufacturing awareness and might have been prepared from the plucked shoots of decreasing plucking period.

Colour index also varied among the studied brands in this experiment (Fig. 2). The results expose that CI ranged from 8.82 (Orthodox green tea) to 10.98 (Black tea) and showed the sequence as Black tea>Green tea>Tulsi tea>Orthodox black tea >Ginger tea >Orthodox green tea (Fig. 2). For better tea, the colour index should be between 5 and 11 in order to have the liquor balanced with colour and briskness. If the colour index value cross 11, then the tea lacks colour and when it falls below 5, the liquor will be coloured and flat with low briskness (Brown *et al*., 1966) [20]. In the present study, the colour index values for all the brands were between 8 and 11. So the colour indices of all the studied brand teas were not up to the mark in respect to Bangladesh tea standard and can be ranked as medium. The status of colour index in the present investigation corroborates with the findings of Alam *et al*. (2011) [45] 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) [60] estimated the colour index ranging from 8.75 to 10.94. This remark is also in full agreement with the CI status of the present investigation.

Briskness index (BI) of this experiment was found to be varied among the studied brands of Ispahani tea (Fig. 3). It is apparent from the result that the highest value of BI was estimated to be 20.89 (Black tea) and the lowest value was estimated to be 19.95 (Ginger tea) and followed the sequence as Black tea>Orthodox green tea>Tulsi tea>Green tea>Orthodox black tea>Ginger tea (Fig. 3). The normal range of briskness index proposed for South Indian 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) [35]. Briskness index values of all the brand teas in the present study were between 19 and 21. So it can be said that liquors of all the studied brands were medium in briskness. Alam *et al*. (2011) [45] 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 the present experiment substantiates with the observations of Alam *et al*. (2015) [60] who worked on five popular marketed brand teas of Bangladesh and estimated the briskness index ranging from 24.76 to 21.88.

Nutrient contents (N, P, K, Ca and Na) also varied with the studied brands in this experiment. The results as shown in Table 2 indicate that maximum concentration of Nitrogen was determined to be 5.25% in Orthodox black tea and minimum concentration was 4.24% in Ginger tea and showed the following sequence as Orthodox black tea>Black tea>Green tea >Orthodox green tea>Tulsi tea>Ginger tea. Foliar nitrogen contents of the satisfactory levels of nitrogen in first leaf is 5.0% & nitrogen contents of 4.4% & 3.8% in the first & third leaf samples respectively represent critical levels (Wilison, 1975) [63].

Table 2: Variation of nutrient contents (%) in six different brands of Kazi and Kazi tea.

Brand	N	P	K	Ca	Na	Total
Black tea	4.92	0.12	2.85	1.38	0.091	9.36
Ginger tea	4.24	0.15	1.64	1.47	0.052	7.55
Tulsi tea	4.55	0.25	1.72	1.24	0.067	7.83
Green tea	4.78	0.21	2.05	1.63	0.074	8.74
Orthodox black tea	5.25	0.16	2.75	1.75	0.079	9.99
Orthodox green tea	4.75	0.17	1.87	1.32	0.082	8.19
LSD at P >0.05	0.46	0.06	0.27	0.23	0.019	0.89

The highest amount of Phosphorus was found to be 0.25% in Tulsi tea as well as the lowest amount was found to be 0.12% in Black tea and followed the sequence as Tulsi tea>Green tea >Orthodox green tea>Orthodox black tea>Ginger tea>Black tea (Table 2). The usual range of leaf phosphorus is between 0.6% & 0.9%, (P_2O_5) and P content of 0.25% or less indicates

its starvation (Choudhury, 1983) [64] which corroborates with the Phosphorus status of the present experiment.

Potassium content was estimated to be maximum in Black tea (2.85%) and minimum in Ginger tea (1.64%) and maintained the given sequence as Black tea>Orthodox black tea >Green tea>Orthodox green tea>Tulsi tea>Ginger tea (Table 2). The concentration of potassium is higher in two leaves and a bud (about 2.0%) than the third leaf. Potassiumconcentration below 1.75% in first leaf with a bud, and 1.57% in third leaf are a clear indication that potassium is limiting yield (Wilison, 1975) [63] which is in full agreement with the results of the present investigation.

In case of Calcium content Orthodox black tea was found to be superior (1.75%) but Tulsi tea was found to be inferior (1.24%) among the studied brands and accordingly showed the following sequence as Orthodox black tea>Green tea>Ginger tea>Black tea>Orthodox green tea>Tulsi tea (Table 2). Desirable calcium content in North- East India is usually about 0.1% calcium (Mann and Gokhale, 1960) [65]. Normal tea leaf as plucked contains an average of more than 0.5% Ca. The concentration of Ca is higher in third leaf (about 1.0%) than the two leaves and a bud (Choudhury, 1983) [64] which bears a close resemblance with the results of present study

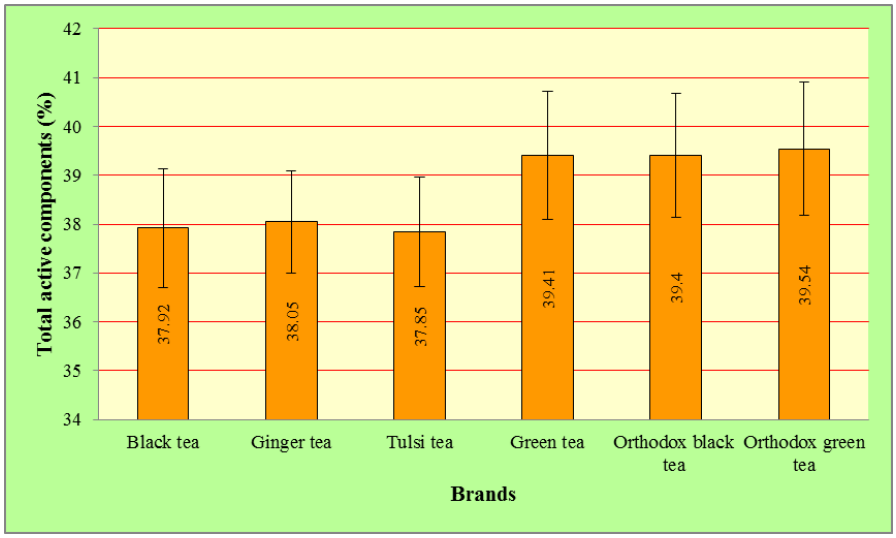

Fig 4: Variation of total active components of quality parameters (Sum of caffeine, TP, TF, TR, HPS and nutrient elements) in six marketed brands of Kazi and Kazi tea.

In concerning the sodium content, maximum amount was evaluated to be 0.091% in Black tea and minimum was 0.052% in Ginger tea and thus followed the given sequence as Black tea>Orthodox green tea>Orthodox black tea>Green tea >Tulsi tea>Ginger tea (Table 2). The sodium content in Pakistani Black Tea was found to be 0.39-0.83 mg/l (Adnan *et al*., 2013) [66] which is persistence with the findings of the present experiments.

Twig nutrient status was found to change with agro-types and periods. N content ranged from 4.33% - 5.76%, 6.07% - 7.51% and 3.77% - 4.99%; P content ranged from 0.194% - 0.241%, 0.124% - 0.213% and 0.181% - 0.227%; K content ranged from 1.72% - 2.39%, 1.74% - 2.93% and 0.86% - 1.31%; Ca content ranged from 1.20% - 1.77%, 0.98% - 1.30% and 1.05% - 1.47%; Na content ranged from 0.068% - 0.090%, 0.084% - 0.184% and 0.058% - 0.092% on increasing, peak and decreasing period respectively period (Chowdhury and Alam, 2001) [41]. The highest average values of N, P, K, Ca and Na contents (average of three plucking periods) were found to be 6.089%, 0.23%, 2.16%, 1.45% and 0.118% respectively whilst the lowest average values were found to be 4.75%, 0.167%, 1.47%, 1.11% and 0.071% respectively in Bangladesh tea. Twig N, K. and Na contents were found to be the maximum on peak period and minimum on decreasing period but P and Ca contents were found to be the maximum on increasing period and minimum on peak period (Chowdhury and Alam, 2001) [41]. Hence, in respect to nutrient contents, it can also be understood that all the studied brands of Kazi and Kazi tea might have been manufactured from the downward shoots of plucking standard and certainly the plucking time was on decreasing plucking period.

It is also apparent from the result as presented in Fig. 4 that in respect to total amount of active components (Caffeine, TPC, TF, TR, HPS and nutrient contents) so far studied in this experiment Orthodox green tea (39.54%) was found to be superior among the six different brands of Kazi and Kazi tea whilst the lowest amount was determined in Tulsi tea (37.85%) and consequently followed the sequence as Orthodox green tea>Green tea>Orthodox black tea>Ginger tea>Black tea>Tulsi tea. In a recent study, it was reported that the caffeine, TF, TR, HPS and TLC contents of Ispahani Mirzapore tea was found to be 2.78%, 0.47%, 4.202%, 3.752% and 1.8 respectively and the total of Caffeine, TF, TR and HPS was determined to be 13.004% (Alam *et al*., 2011) [45].

Conclusion

The present study concludes that the six brands of Kazi and Kazi tea might have been harvested in decreasing plucking period (October-December). The Caffeine, TP, TF, TR, HPS, TLC, N, P, K, Ca and Na contents of six studied brands of tea were medium in quantity but comparable with qualitative standard of Bangladesh tea. Above all, the plucking standard was not maintained properly and there might have been followed the standard of a bud with four leaves or downward plucking. It can further be concluded that in respect to qualitative status so far studied in this experiment Orthodox green tea was found to be superior among the six different brands of Kazi and Kazi tea but all of the brands could be defined as medium quality tea.

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