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Full Length Research Paper

Effects of clonal variations on the Chemical and Organoleptic Qualities of Green Tea processed on Mambilla Highland, Nigeria

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Green tea was processed from seven different tea clones 68, 65, 35, 228, 236, 318 and 143 in this study using Chinese method of green tea processing which include, Plucking, Fixing, Rolling and Drying. Mineral elements, Polyphenols, Tannin, Caffeine, Vitamin C and β-carotene of the processed green tea were evaluated. The Sensory evaluations of the Green tea infusions was carried out to determine the effect of tea clonal variations on the sensory attributes of taste, colour, aroma, and overall acceptability. The results obtained in this study indicated significant variations (p<0.05) in mineral elements based on clonal differences. Heavy metal elements were in the range of 0.011-0.32ppm for Cd, 0.001-0.005 for Ni and 0.09-0.27ppm, for respectively. The safety of all these samples were assured as their contents were significantly lower than the values within the safety threshold as speculated by WHO. Some trace metals like Iron, Fe; Nickel, Ni, and Zinc Zn, which are essential, for growth also varied significantly (p<0.05) and ranged between 30-250ppm for Iron, 0.001-0.005, for Ni, and 33.67-52.6ppm for Zinc respectively. Some agronomic factors might have played a significant role in the mineral constituents' as evidenced in this study. The choice of clones for mineral components will depend on high contents of essential elements such as Magnesium, Iron, Zinc, low contents of toxic/heavy metals like Cadmium, Lead, and Nickel. Low caffeine, low tannin, high polyphenol, high vitamin C, High β-carotene and organoleptic values. Based on all these parameters, our findings established that clone 68 has a high levels of essential elements: Zn (52.6ppm), ; Fe (180ppm), K (70.37ppm), and Sodium (44.47ppm). The Caffeine content ranged between 1.29-2.56% w/w with a mean of 192% and differed significantly from clone to clone. The total polyphenols TPC ranged between 22.1% -53.4%. Vitamin C of the green tea also varied significantly with clonal variations. Clone 35 had the highest vitamin C content of 0.46% followed by clone 236 (0.365%), cone 61 (0.17%), clone 68 having 0.11% of vita min C. The percentage Tannin of the green tea was relatively low. β-carotene also varied according to the clones and is in the order 35>318>61>363>68>228. Sensory evaluation showed significant differences among the green tea infusions in taste, aroma, colour and overall acceptability.

Key words: Green tea, clones, elements, heavy metals, organoleptic

INTRODUCTION

Green tea is one of the three most popular beverages besides coffee and cocoa (996). Green tea is composed of about 30% of polyphenols (Dry basis), such as flavanoids, flavanols, and phenol acids. Polyphenols have been well known to have various excellent

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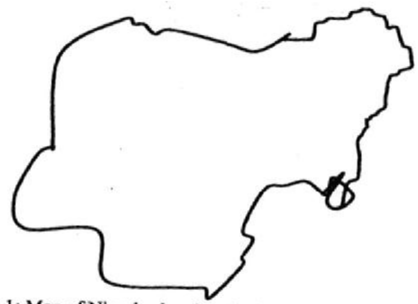


Fig 1: Map of Nigeria showing the location of Taraba State

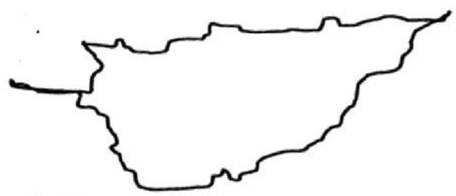
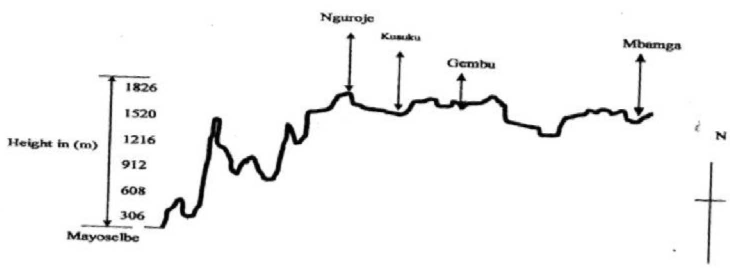


Fig 2: Map of Taraba State showing the location of Sardauna local Government



Topographical view of the Mambilla Plateau, Nigeria

biological activities for example; inhibition of tooth decay (Sakanaka, Kim, and Yamamoto, 1989), inhibition of allergy (Yeo, Ahu, Lee, Park, and Kim, 1995), prevention of gout (An, Bae and choi, 1996) and inhibition of oxidation. Especially the inhibitory effect of green tea polyphenol on lipid oxidation was higher than that of the synthetic antioxidant Butylated Hydroxytoluene (BHT) Chen, Chan, Ma, Fung and Wang, 1996). World production of different beverages from the young tender shoots of Tea (*Camellia sinensis* (L) O. Kuntze) has continued to rise (Anon, 2005) despite lack of commensurate increase in consumption. One way of improving the profitability of tea production is by planting high yielding clones with excellent quality. But high quality tea can be obtained within the correct quality potential. However, quantifiable breeding or selection criteria for quality have been elusive. Past tea breeding /clonal selection put emphasis on yield (Seuries, 1997) and whatever quality material is in production now might not have been selected for this attribute. Traditional selection//breeding methods for the tea have relied on a combination of morphological characteristics, which are somewhat empirical, slow and laborious to assess (Njuguna, 1984). Much high yielding and good quality planting material has evolved by chance. Sensory evaluation has been the only method of assessing tea routinely but is applied after processing Many reports are available in the literature on research works carried out on the agronomy, soils, and plant breeding of Nigerian tea and recently, reports on processing and utilization are prominently appearing in various journals. Development of green tea technology is being introduced as a way of diversifying into new product with high economic and medicinal benefits such as anticancer, anti diabetic, anti tumour, anti obesic, anti halitosis, anti aging and stimulating properties of green tea. Since this is a new technology in Nigeria with no information in the literature, this study was designed with the objective of using some selected tea clones obtained from the highland of Mambilla , Nigeria in producing green tea and evaluating the effects of the different clones on the characteristic chemical and sensory qualities..

MATERIALS AND METHODS

Green tea leaves were harvested from tea Germplasm plot of the Cocoa Research Institute of Nigeria, Kusuku, Mambilla located on highland around 1840m above sea level, latitude 5^{O} 30´ N and longitude 11^{O}37 ´E. It has a

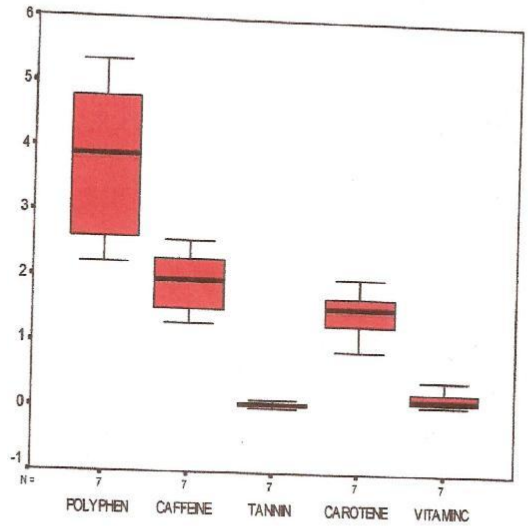


Figure 2a. Box plot showing the variation in total Polyphenol, Caffeine, Tannin, b-Carotene and vitamin C of green tea from different clones

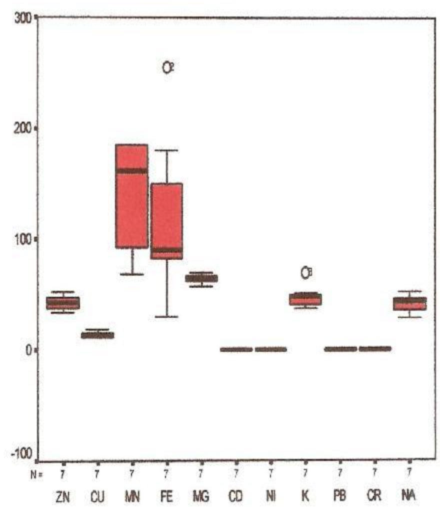


Figure 2b: Box plot showing the variations in chemical elemnetns of green tea from different clones

total land area of 3,765.2km^2 forming the southernmost tip of the Northeastern part of Nigeria (Fig 1, 2, 3). Its altitude ranged from 1216m above mean sea level to 1840m (amsl). The climate of the Plateau is remarkably semi-temperate (montaine). Approximately the land area covered with tea plantation is about 1200hectares.The mean annual rainfall 2300mm. The tea clones were selected which had shown good quality potential i.e. drought résistance, pest/disease resistance and high yielding varieties. Except for clones 68 and 363, all clones used in this study are being used for commercial purpose. The plantation was receiving uniform agronomic treatment, with fertilizer at 150kg-1Ha as N.P.K. 25:5:5.5. Tea is harvested with hands by team of pluckers from the tea bushes. The harvested crop includes bud + 1 leaf from seven clonal tea materials 228, 318, 68, 35, 363 and 236. The harvested leaves were processed in to green tea using Chinese methods viz: Plucking, withering, Fixing (Pan fixing to inactivate the activity of polyphenol oxidase enzyme), Rolling and Drying. The dried green tea samples were ground using pestle and mortar. The pulverized and powdered green tea samples were treated in an identical manner. For acid digestion, green tea (0.25g) was weighed into a pre-cleaned beaker, concentrated Nitric acid (10ml) was added, the beaker was covered with a watch glass and the sample was boiled gently on a laboratory hot-plate until digestion was complete. This process took approximately 3h.The digested sample was then allowed to cool down before being transferred quantitatively into clean 25ml volumetric flasks. The samples was then made up to volume by the addition of ultra pure water. Four replicates digestion were made for each tea clone. To ensure that the results obtained for the Analysis were accurate, a certified reference material (Chinese reference material GBW 08505, obtained from the bureau of Analyzed samples, Middlesbrough, UK) was prepared the same way.

Chemical Analysis

Tannin Determination

The determination of Tannin was done by a method based on formation of insoluble tannin salts with copper II cation. This include extraction of tannin with boiling water followed by precipitation with copper II acetate and filtering after 12h. The final precipitate was calculated from a proportion considering the quantity of copper taken fro analysis and quantity of copper II oxide bound by tannin (Cisowski *et al*, 1995).

Vitamin Analysis

Vitamins such as β – carotene and Ascorbic acid were analyzed by standard AOAC 2000 method

Total Polyphenols

Total phenol content of the different tea samples was determined using Folin Dennis Ciocalteau reagent (Singleton *et al,* 1999). Briefly, to 0.025ml of each tea sample previously diluted (2.5 x), 1.5ml of water was added followed by 0.125ml of Folin Dennis Ciocalteau reagent and mixed. After 1 minute, 0375ml of 20% $Na_2 C0_3$ and 0.475ml of water for 2h at room temperature in the dark. The absorbance was then measured at 760nm against a blank containing water instead of tea. For determining Total Phenol content, standard concentration of Gallic Acid (0-80uM) were used for plotting the calibration curve (Mm Gallic acid versus absorbance). Gallic acid stock solution was prepared in ethanol at a concentration of 26.5mM. The results were expressed as mM Gallic acid equivalent (GAE).

Determination of Caffeine

The caffeine was determined spectrometrically. The tea infusion was prepared by diluting 2g of the green tea leaves in 100ml of distilled water. Twenty five milliliter of the infusion/brew was transferred to a separating funnel and 2ml of Analar ammonia solution was added. A pale yellow colour turned pink. 25ml of chloroform was then added and extraction of caffeine took 30 seconds by shaking. The optical density of the chloroform layer at 276.5nm was then measured. The % caffeine was then calculated by comparison with optical density of extracts from aqueous solution of known concentrate.

Sensory Analysis

Green tea infusion was carried out following the standard protocol according to Roberts, 1966. 2g of green tea (loose) leaves were infused in hot water previously boiled to 90OC. The different infusions were served in a transparent glass bottles without milk or sugar. 20 panelists were recruited from the Cocoa Research Institute of Nigeria, Kusuku station Mambilla Highland Nigeria. The panelists sat close to each other in a tasting booth with a wooden barrier in between tasters to prevent interaction and causing undue bias in judgment. Panelists were supplied with cold water to rinse their mouths after each round of tasting Coded samples of green tea infusions were served to the panelists as GTI_{228}, GTI_{363}, GTI_{61}, GTI_{35}, GTI_{68} and GTI_{236} respectively. Panelists carried out the sensory evaluation in a well ventilated room with high illumination. The panelist were asked to rate all the green tea infusions in taste, aroma, colour and overall acceptability using 9-point hedonic scale, 9 – like extremely and 1-dislike extremely

Statistical Analysis

The data generated were subjected to Analysis of variance (ANOVA) and themeans were separated using t-test. Box plots were also used to determine standard error of means of the chemical components as well as the vitamins, caffeine and Tannin

RESULTS AND DISCUSSION

Table 1 showed significances among the green tea samples from different clonal materials on the Mambilla highland, Nigeria in chemical components. Variations in heavy metals was observed and ranged between 0.011-0.33ppm for Cadmium, 0.001-0.005ppm for Nickel, and 0.09-0.27ppm for Lead respectively. Exposure to various metal components of tea varied widely and may have

Table 1. Metal elements in green tea processed from selected tea clones from the Mambilla Highland, Nigeria.

Tea Clones	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Mg (ppm)	*Cd (ppm)	*Ni (ppm)	K (ppm)	*Pb (ppm)	Na (ppm)
228	46.53	12.73	69.23	90	65.20	0.018	0.002	48.15	0.113	36.62
318	34.90	16.36	184.62	180	57.70	0.007	0.004	48.15	0.12	47.48
68	62.65	18.18	184.62	255	62.83	0.033	0.002	70.37	0.19	44.49
35	47.76	10.91	69.23	30	69.18	0.022	0.001	44.44	0.27	29.34
61	33.67	10.91	115.38	120	67.04	0.009	0.001	37.04	0.21	36.62
363	41.02	14.55	184.62	75	61.91	0.031	0.005	37.04	0.14	52.60
236	42.86	10.91	161.54	90	70.48	0.011	0.004	51.85	0.09	44.37

Zn; zinc; Cu; copper; Mn; manganese; Fe; Iron.,, Cd, cadmium, Ni, nickel; K, potassium, Pb, lead; Na, sodium; *Heavy metals (Cd, Ni, and Pb)

varying health implications (Soomro *et al*. 2007). Depending on the clone, variation in the heavy metals accumulation could be as a result of soil contamination, use of pesticides and fertilizers (Ebadi *et al,* 2005).

Some trace metals Iron (Fe), Nickel (Ni) and Zinc which are essential for growth also varied significantly and ranged between 30-255ppm for Iron; 0.001-0.005ppm for Nickel and 33.67-52..6ppm for Zinc. Although these elements are trace, they are essential for growth while the Lead, Nickel and Cadmium are not only biologically non essential but toxic (Shukla *et al.,* 2007). A very important biological property of metals is their tendency to boiaccumulate. Bioaccumulation is therefore essential in hazard evaluations strategies; for example, daily dietary intake of Zinc was 2.13% while percentage available for absorption in the intestine was 0.72% (Moghaddam *et al*., 2007, Racch *et al,* 2010. The extent of physiological disturbances depends on uptake and bioaccumulation oif these metals (Shukla *et al.,* 2007; Seenivassen *et al*., 2007). The presence of heavy metals in tea has become a world wide study. For example, Iron and Copper in Poland (Gramza *et al.,* 2005), Copper in India and US (Kumar *et al.,* 2005) have recently become the subject of wide spread concern, since beyond the tolerable limits they become toxic (Koller *et al,* 2004), Tautikus *et al.,* 2004. The values obtained in this study for the trace metals of the different green tea from selected clonal varieties are favourably comparable to data reported by Albert and Owoeye, 2010 in some tea marketed in Nigeria (majorly black tea) and were all within tolerable limit. The range of Cadmium reported in their study were higher than values obtained in our study (0.37ppm-2.75ppm) Cu (2.33ppm-5.69ppm; Fe (442.95-1716.6ppm); Mg (41.1-244.56ppm), Pb (0.00-0.11ppm and Zn (-0.03ppm) Albert and Owoeye, 2010. The difference in values might be associated with the processing methods (Black being different from green tea. Apart from difference in processing of different tea, some agronomic factors might have played a significant role in the mineral elements available in the final green tea produced from the clones. According to our findings, the metals recorded in lowest concentration (< 1.00mg/kg) were Cadmium (Cd, Nickel and lead) which differed significantly according to clones. The metals present in greatest concentrations are Fe (75-255ppm), Mn (69.3-184.62ppm); and Na (29.34-52.62ppm) followed closely by highly toxic element Cu (10. 91-18.18). The results obtained in this study was in conformity with the data reported by Albert and Owoeye, 2010 . The numerical values of metals like Fe, Mg, K, and Na varied widely according to clones. The results of total contents of the studied heavy metals and trace metals in the green tea compared favourably well with tea grown in other countries.. The differences in metal contents (trace, heavy, alkali metal and alkaline earth metals) as evidenced in this study could be due to their geographical origin (Weedpohi, 2000) or due to leachate characteristics of soil. Long term plantation of tea can also result in acidification and elevated concentration of bioavailable heavy metals in the soil; therefore enhance the risk of heavy metals accumulation in tea leaves. Variations in the elements of the different green tea processed from different tea clones as evidenced in this study could also be due to brewing characteristics, tea particle size and weight, element extraction rate and efficiency, water temperature, tea/water ratio (Lakabriah *et al*, 2000. The choice of clonal variety for mineral elements will depend on low contents of toxic/heavy metal elements like Cadmium, lead and Nickel and high contents of essential elents like Fe, Mg and Zn repectively. In essence, clones with high levels of essential elements according to our study are clones 68: Zn (52.65ppm), Fe (180ppm), K (70.37ppm) and Na (44.49ppm. All the green tea from the different clone showed a favorable quantities as they fell within level tolerably intake as recommended by the WHO, 1998 and their heavy metals were all less than 1mg (WHO,1998).

Caffeine

Caffeine is an alkaloid whose basic structure is purine and available in tea, coffee, cola nut and cacao. Caffeine is extensively used in non-alcoholic beverages and also in pharmaceuticals because of its stimulant and muscle relaxant properties. Clonal differences was observed in

Table 2. Chemical components of Green tea produced from 7 tea clonal varieties on the Mambilla highland, Nigeria.

Clones	% Total Polyphenol	% Caffeine	% Tannin	% Carotene	% Vitamin C
228	4.62	2.18	0.127	0.90	0.13
318	5.34	2.56	0.016	185	0.16
68	2.21	1.29	1.68	0.087	0.11
35	2.87	1.68	0.087	2.02	0.46
61	2.37	1.37	0.067	1.58	0.46
363	3.87	1.96	0.10	1.47	0.07
236	4.95	2.39	0.08	1.55	0.36

- Total polyphenols was determined using Folins Dennis Ciocalteau reagents.

the % caffeine of the green tea and is significant at p<0.05. with means 1.92% (Table 2). Earlier studies have shown that caffeine contents of tea are affected by clones, season or stage of plucking (Hara *et al.,* 1995; Harbowy and Balentine, 1997; Owuor and Charvanji, 1986). As was evidenced in our current findings, since all the tea clones were grown under the same climate and same agronomic conditions, the variations in the caffeine might not be due to environmental, but could be due to age of the tea leaves as young leaves contain more caffeine than older tea leaves (Fermuz *et al.,* 1993). The production of green tea in this study follows the same steps and the materials used were from 1 bud and 1 leaf. Owuor and Charvanji, 1986, reported that caffeine contents in 1 bud with 5 leaves had fallen to 2.91% (w/w) from 1 bud with 2 leaves of 4.88% (w/w). The clonal variations might play a significant role in the caffeine in our study. However, infusion temperature and time could also have a significant effect on extracted into the solution (Hicks *et al*.,1996; Owuor *et al*., 1997; Yao *et al*., 1992; Lee *et al.,* 2007; Park *et al.,* 2007) The range of caffeine recorded in our study r supported the hypothesis of Liu *et al*., 2006 who stated that green tea could have same % caffeine content with black tea. Other researchers have postulated that increase in plucking round and shooting periods might also contribute to caffeine levels in tea. Variations in the caffeine contents found in our study could be due to the clonal differences which could be the effect of the genetic diversity of the clones (Fermuz *et al.,* 1993).

The caffeine contents varied significantly accordingly to the tea clone. The green tea caffeine from clone 228,318 and 236 were within the standard level of 2-5%. Other clonal varieties like clone 61,35,68 and 363 were relatively low in caffeine. Caffeine is an important component of tea. Green tea contains abundant caffeine, which is an alkaloid that can have negative effects on the human body depending on the level of intake. Less than 300mg intake per day is not harmful for adults, but an intake of more than 500mg has been shown to cause excessive excitation in the central nervous system and cause arrhythmia and vertigo (Paspa and Vassailla, 1984, Seale *et al.,* 1984) Since not all the body can withstand the strong caffeine in the system, green tea from clones 61,35,68 and 363 can be good material for producing green tea, with clone 61 being the best for individuals interested in caffeine less green tea. It is noteworthy therefore that close attention should be placed on caffeine intake by children and pregnant women because it is slowly metabolized and can remain in the body for a prolonged period (Giannelli *et al*, 2003; Rasch, 2000). Accordingly, the removal or marked reduction of the caffeine content of green tea has been actively attempted by establishing a new technique called decaffeination in the manufacturing process. Methods using organic solvents, supercritical carbon iv oxide and hot water have been reported for the decaffeination of green tea (Lee *et al.,* 2007; Liang *et al,* 2007;Park *et al.,* 2008. Park *et al.*, 2007). The combination of good yield coupled with processing potential of the clone should be used as a base for plant breeders to develop a clone that can be recommended for use in the processing of green tea with the minima caffeine content.

Tannin, Vitamin C, β-Carotene and Total Polyphenol

Other quality characteristics of the fresh leaves which affect the quality are 1. The tenderness of the fresh leaves and 2. The polyphenol contents. The total polyphenol obtained in this study ranged between 22.1%-53.4%. The trend in the polyphenol is shown in table 2 and in descending order of magnitude is 318>236>228>363>35>61>68. The polyphenols and their transformation products are responsible for unique characteristics of tea (Anon, 2005). The percentage polyphenols (mg/g Gallic acid) as evidenced in this study seemed to be high. Other reports have shown range of polyphenol values in tea to be 25-35%. Our data have shown that four out of seven clonal materials used in this work representing 57.2% were higher than 35%. The difference in values might be due to the materials analyzed by the author which might be due to geographical origin of the experimental materials, season of plucking, plucking rounds, topographical; variations among others. Other researchers have reported that

Table 3. Sensory evaluations of Green tea samples from different clonal varieties obtained from the Mambilla Highland, Nigeria.

Infused green tea	Taste	Aroma	Colour	Overall acceptability
228	8.00±.22a	7.00±.0.12b	8.00±.0.21a	7.00±.0.11b
318	7.00±.0.21b	8.00±.0.04a	8.00±.0.13a	8.00±.0.01a
68	7.00±.0.00b	8.00±.0.00a	7.00±.0.01b	7.00±.0.00b
35	6.00±.0.01c	7.00±.0.22b	8.00±.0.20a	8.00±.01a
61	7.00±.0.21b	7.00±.0.1b	7.00±.0.11b	7.00±.0.00b
363	6.00±.0.02c	7.00±.0.01b	7.00±.0.03b	7.00±.0.12b
236	8.0.±.0.11a	8.00±.0.11a	6.00±.0.22c	7.00±.002b

there could be variations in some chemical properties of green tea based on all these factors which could be a possibility in our case. Some other researchers have postulated that contents of total polyphenols in tea could be due to colour of the tea leaves; light green, heavy green and purple leaves were reported to have 31.37%, 28.54% and 30.84% of polyphenols (Anon, 2008). Other factors such as tenderness also contributed significantly; a bud is reported to contain 20.30% , bud + 1 leaf 20.54% , bud +2 leaves, 20.59%, bud + 3leaves, 21.39%, bud + 4leaves , 15.86% (Anon, 2008). The polyphenol in our study was higher than the ones reported by Anon, 2008 despite the fact that the material that was used in our study was 1 bud +1 lea. (Vendetti *et al*, 2010 observed that levels of total polyphenols changed with steeping time of the tea leaves in water (Cold or hot). He observed that total polyphenol content is always higher in hot teas than in cold tea especially green tea. Vasundhara *et al*., 2008 also reported changes in polyphenols of black tea as a result of influence of milk and sugar. He observed that tea infusions without sugar or milk possessed maximum amount of polypohenols.

With regards to vitamin C (ascorbic acid), the contents of it varied considerably according to the clones. Clone 35 had the highest vitamin C contents of 0.46% followed by clone 236 (0.365%), clone 61, (0.17%), 318 (0.16%), clone 228 (0.13%) and least in clone 68 having 0.11% of vitamin C. The mean average vitamin C in our study fell within 0.11% - 0.46%. The vitamin C levels in all the samples was desirable though some vitamin C components might have lost during drying and storage. Ascorbic acid (vitamin C is an essential components of the human diet. Moreover, vitamin C enhances iron absorption (Cook and Redd, 2001) and is important in preventing megaloblastic anaemia of infants (Jacob, 1994) and also reduces stomach ulcers (Henula and Herman, 1995). In our study, it was observed that % tannin of all the examined tea clonal varieties were lower than those reported in the literature (Anion, 2008), the low tannin contents was coupled with significantly high vitamin C. Decreased tannin and increased vitamin C concentration are significantly useful for iron absorption and improved digestion (Chand and Gopal,2005).

The presence of β- carotene as sown in table 2 is an advantage as studies have shown that vitamin A play an important role in iron metabolism (Chand and Gopal, 2005). Significant variations occurred in β- carotene of the tea clones. Clone 35 had the highest concentrations of β- carotene of all the tea clones. The trend in the β- carotene in descending order of magnitude, however is clone 35>clone 318>clone 61>clone236>clone>363> 68>clone 228. Reports have indicated that β- carotene constitutes about 95% of total xanthophylls in the first leaf (Anon, 2008). It was speculated that the degradation of carotene compounds will yield volatile compounds which contribute to the characteristics aroma generated during processing (Anon, 2008).

Sensory Analysis

The results of the sensory evaluations was shown in table 3. Significant differences were observed in all the green tea infusions with different clones in attributes of taste, colour, aroma and overall acceptability. In terms of taste, clone 236 seemed to be significantly better than other clones as panelists considered it to have a prominently less bitter taste. It was not significantly different from clone 228 but significantly different from other clones 318, 68 and clone 61. Clones 363 and clone 35 were rated low because of their significantly high bitterness. In aroma, clone 236, 68 and 318 were rated high among the green tea infusions when compared to clones 228, 35, 61 and clone 363 respectively. The scores of the panelist in the clone 35 aroma contradicted the chemical score of its β- carotene which was highest in values. The hypothesis that aroma of green tea can be influenced by β- carotene values and its degradation products is however disputed by this findings. This sis possible as panelist may record their observations subjectively. In terms of colour , clone 35, 228, 318 appeared to be significantly different and higher in values than all the other clones. No significant difference was observed ($p<0.05$) in colour of tea from clone 68, 61 and clone 363 respectively. In overall quality assessments, panelists observed that clone 35 and clone 318 were the best.

CONCLUSION

It was observed from this study that variations in tea clones was responsible for the diverse chemical components of the green tea and using ranking of the tea clones using quality markers like High polyphenols, Low caffeine, low tannin, high vitamin C, high b-carotene, the performance of the clonal materials in descending order of ratings are TP: 318>236>228>363>35>61>68; low caffeine: clone 68>61>35>363>228>236>318; low tannin: clone 318>68>61>236>35>363; High vitamin C, 35>236>61>318>228>68>363; High β- carotene. 35>318>61>236>363>68>228 and the overall acceptability in terms of organoleptic scores where clone 318= clone 35>228=clone 68=clone 61=clone 363=clone 236. It is clear , however that the most prominent clones in desirable quality attributes for green tea production as shown in our results are clones 35 and clone 318. The blending of the two clones will be necessary in view of the contents of desirable components that one is having which is lacking in the other. Plant breeders may need to crossbreed clones having a different desirable components with another having less of that but another which the other one is not having in abundance.

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