ABSTRACT

Near about two-third of the world population consumes tea [*Camellia sinensis* (L.)]. Three distinctly different tea growing regions were noticed in North Bengal. In therapeutics, various kinds of tea matrices obtained from different grades of tea are most often employed for prophylactic purposes and in the formulation of plant derived elixir to protect human diseases.

The present studies were conducted during 2006-2010 in ten cultivars of tea (*Camellia sinensis* (L.) O. Kuntze) namely, TV1, TV20, TV26, TV29, TV30, Tinali 17, Takda 7, 8, Tingamara, Sundaram (B/5/63) and Dangri Manipuri at tea estates of Terai, Dooars and Darjeeling hills of North Bengal. Commercial standard plucked tea leaves were assayed to determine antioxidant activity and related phytochemical constituents. DPPH was used to determine the antioxidant properties of bud+leaf (B+L), bud+two leaves (B+2L), bud+ three leaves (B+3L) and mature leaves (L). Subsequently, total phenolics, f1avonols and hydrolysable tannins were estimated using standard methods. The result showed that free-radicals scavenging potentiality and chemical composition varies significantly at different growing conditions and leaf maturation. Statistical analysis showed significant relation between antioxidant and some phytochemical composition of dry tea leaves, among which phenolics (R^2 = 0.904, P< 0.00 I), tannins (R^2 = 0.567, P< 0.05) and flavonols (R^2= 0.314, P< 0.05) bear significant correlation. Soil physicochemical parameters like pH (R^2= 0.537, P< 0.05), nitrogen (R^2= 0.618, P< 0.0 I), K_2O (R^2= 0.1 06, insignificant), P_2O_5 (R^2= 0.730, P< 0.01), S (R^2= 0.1 57, insignificant) and soil moisture (R^2= 0.745, P< 0.0 I) influenced free radical scavenging activity in tea leaves. Antioxidant quality of tea varies with maturation stages of leaves and the pattern is specific for a selected varieties. From our observation it may be concluded that antioxidant quality is dependent on some fertility parameters of soil and maturation of leaves.

Also, this thesis reported the occurrence of 24 species of shade trees in tea plantations on various soil conditions in North Bengal region. The prevailing soil types and different soil characteristics have been recognized in the study area.

Climatic variation of Phenolics (mainly EGCG and ECG), flavouring index (TF: TR and HPS, TC), PPO activities and anti-oxidative properties in fresh tea shoots to handmade orthodox tea, consisting of one apical bud and two adjoining leaves

sampled from TV-1, TV20, TV26, TV29, TV30 (Tocklai vegetative) clone and Tingamara, Dangri Manipuri and Sundaram (B/5/63), Tinali 17, Takda7.8 grown in Terai, Hill and Dooars region in North Bengal, were investigated during three harvest season (March, June and December) in 2007, 2008, 2009 and 2010. The EGCG, ECG of all clones was lower in cool months of December in four years (average 4.90 - 2.15, 2.93-0.63). Thereafter, the levels of total phenolics in terms of EGCG and ECG increased throughout the warmer months from March to September. Antioxidant activity showed similar trends which increased from 1st harvest (March) to 3rd harvest (December). All clones showed nearly 100% antioxidant activity at 2nd and 3rd harvest season which was higher than standard synthetic antioxidant BHA (Butylated hydroxyl anisole). However, seasonal diurnal variation of phenolics showed different results according to clones used. TF: TR (0.138 to 0.036%), HPS (22.235-10.14%) and TLC (5.73-3.49) also seasonally vary. PPO activity plays a crucial role and depends on the clone.

Agro-climatic variation of antioxidative properties, phenolics and mineral nutraceuticals in fresh tea shoots, consisting of one apical bud and two adjoining leaves sampled from TV1, TV20, TV26, TV29, TV30 (Tocklai Vegetative) clone and Tingamara, Dangri Manipuri and Sundaram (B/5/63) grown in Terai region in Darjeeling district, North Bengal was investigated during three harvest season (March, June and December) in 2007, 2008 and 2009. The total Phenolics of all clones were lower in cool months of December in three years (average 36.02-93.29 mg GAE/g dry weight basis). Thereafter, the levels of total phenolics increased throughout the warmer months from March to September. Antioxidant activity determined by DPPH based free-radicals scavenging assay showed similar trends which increased from 1st harvest (March) to 3rd harvest (December). All clones showed nearly 100% antioxidant activity at 2nd and 3rd harvest season which was higher than standard synthetic antioxidant BHA (Butylated hydroxyl anisole). However, seasonal variation of minerals (N, P, K, Ca, Mg, Na, Fe, Cu, Mn, and Zn) showed different results according to clones used.

Tea, which is one of the most popular beverages worldwide, is obtainable from aqueous infusion of processed tea leaves (*Camellia sinensis* (L.) O. Kuntze). In India, mainly three types of tea are produced: viz. Crush-Tear-Curl (CTC), Green and Orthodox tea. From therapeutic viewpoint, green tea has been most widely studied due to its richness in different catechin derivatives. CTC and Orthodox tea is mainly used

as beverage due to high aroma, flavour and brilliant colour. Conventional orthodox processing consists of rolling the leaf, stretching and tearing followed by fermentation, which during CTC preparation, being replaced by quicker and more severe leaf disruption followed by more oxidation process due to wider surface area of interaction of polyphenols with oxygen by polyphenol oxidases (PPO) and peroxidases (PO) enzyme. However, in case of green tea, withered leaves are steamed and dried for minimizing chemical and enzymatic reactions. Industrial processing of tea starts with harvesting phase. Our study suggests that harvest time is crucial for determining antioxidant potential of fresh tea shoots. The total phenols of TV clones were lower in cold season, whereas increased throughout the warmer months from March to September. Antioxidant activity showed similar trend which increased from 1^{st} to 3^{rd} harvest comparable with standard synthetic antioxidant BHA (Butylated hydroxyl anisone). Among different TV clones, PPO activity was found to be highest in TV1. There are biochemical and enzymological changes associated with withering periods. PPO enzyme showed maximum activity after 10 hours of withering whereas PO activity increased continuously with withering time. Highest polyphenols was recorded after 14 hours of withering. Withering temperature is also important for individual catechin species and total catechin accumulation. Higher temperature particularly degrades the level of catechin to a substantial extent along with antioxidant activity as measured by scavenging of DPPH and $ABTS^{\cdot +}$ radicals. Metal chelating activity on the other hand, was enhanced with withering temperature. In case of CTC processing, antioxidant activity was drastically reduced immediately after rapid crush-tear and curl process. However the antioxidant activity of Orthodox tea is quite high even after firing indicating that slow and limited oxidation during fermentation is helpful for restoration of antioxidant activity. Also polymerization of phenols by enzymatic oxidation reduces antioxidant activity in CTC tea as revealed from higher abundance of hydrolysable tannins and quinone in those grades. When different CTC grades were compared, OF and PD was found superior than others in terms of quality and quantity of antioxidants and phytochemicals. Flavour index along with antioxidant activity vary widely with fermentation time and temperature and best fermentation environment was optimized at 60 minutes with 35º C temperature for preparation of better quality tea. Changes in profiles of flavonoid pattern during industrial processing were also revealed from thin layer chromatographic analysis. When compared with different industrially prepared tea of North Bengal, CTC black tea was found to be inferior in

antioxidants and bioactive compounds. In a nutshell, it can be stated that physicochemical attributes during industrial processing might have profound influence for determining quality framework of made tea.