

Effects of Plucking Standards on Clonal Tea (*Camellia sinensis*) Selenium and Aluminum Levels

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ABSTRACT

Aluminum (Al) and selenium (Se) are important elements in human health, being a cause of Alzheimer's disease and reducing cancer risks, respectively. Tea beverages are the most popular drinks in the world and could be a major contributor of the element to human diets. Plucking and cultivars are important agronomic/cultural inputs in tea production and the partitioning of key elements varies with plucking standards/leaf age and cultivars. Although the recommended plucking standard is uniform in Kenya, the practiced standard varies among farmers. Clones TRFK 6/8, AHP S15/10, TRFK 31/8, and EPK TN14-3 are important cultivars widely cultivated in East Africa. However, the variations in these elements with plucking standards and cultivar is not documented. This study determined the variations in Al and Se in tea leaves due to plucking standards and clones. Se levels declined ($p \leq 0.05$) while Al levels increased ($p \leq 0.05$) with coarse plucking standards. There were clonal differences ($p \leq 0.05$) in the accumulation of the two elements in tea leaves. However, the patterns of changes in the elements with plucking standards varied in different clones, causing significant ($p \leq 0.05$) clones x plucking standards interaction effects. Proper selection of plucking standards and selection of cultivars can be used to control levels of these elements in tea and hence the tea brews. At the recommended plucking standards of 2 leaves and bud plucking standard, both Al and Se were within CODEX recommended ranges in all clones. Irrespective of clones, this plucking standard will ensure levels of these elements are within the recommended levels.

Keywords: Selenium, Aluminum, *Camellia sinensis*, plucking standards, clones

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INTRODUCTION

Selenium has received considerable attention for its potential role as a chemoprotective agent.^{1,2} Se is required in low concentrations ranging from 0.1 to 1 $\mu\text{g/g}$ in food for human health³, but becomes toxic at higher concentrations and may even promote carcinogenesis.^{4,5} It plays important roles in detoxification, enhancing immune responses, and has antioxidant and anti-carcinogenic properties.^{6,7} Adequate doses of Se in foods are associated with low incidences of different cancers such as cancer of the liver, colon, breast and skin.^{8,9} More than 25 seleno-proteins have been identified, most of which protect the body against oxidative stress, maintain defence against infection and regulate growth and development.^{10,11} Se is an essential contributor to the enzyme glutamine, which has an antioxidant role in the human body.¹² In humans, Se is absorbed and incorporated into proteins.

Tea beverages are popular and the most consumed fluids after water.¹³ The tea beverages can therefore be major suppliers of essential elements. Green teas containing selenium have high antioxidant activities^{14, 15}. In China, green tea leaves have been shown to be a safer and effective source of supplementation of human selenium intake.^{16,17} In Kenya, a study claimed that esophageal cancer incidences were positively related to high Se levels in tea consumed in Bomet.¹⁸ In a subsequent study,¹⁹ levels of the Se in tea from Bomet County were shown to have Se levels between 0.01 to 0.46 $\mu\text{g/g}$, which was within the acceptable levels in most foods.³ The recommended safe and adequate daily intake is 0.05 to 0.2 $\mu\text{g/g}$ for people above the age 7 years.²⁰ The composition of constituents of plants is heavily dependent on the agronomic practices.²¹ In tea production, plucking standards^{22,23} and cultivars^{23,24} are key factors influencing the composition and quality of tea. However, it is not documented if cultivars and plucking standards influence tea Se levels in tea.

Aluminum (Al) is toxic to humans. High levels of Al in the brain damage not only the nervous system, but also the cardiovascular, hepatobiliary, respiratory, endocrine, and urinary systems.²⁵

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Epidemiological studies showed that excessive Al in the body might lead to Alzheimer's disease (AD), osteomalacia, dialysis encephalopathy, microcytic anaemia, etc.^{26,27} Hundreds of millions of people drink tea daily for health benefits, including antioxidant activity, preventing cardiovascular diseases, and weight management.^{28,29} However tea plant is an Al accumulator³⁰, which is mainly accumulated in leaves.^{30,31} The acceptable daily intake of Al is 1.0 ppm³² or 1 to 10 ppm.³³ Al toxicity in humans was established as a result of studies of disorders experienced by dialysis patients when the dialysis fluid contained Al at or above 0.5 ppm. In such patients, Al accumulated in various tissues, including the kidney, liver, bone and heart.³⁴ Tea, despite being produced from young shoots, contains high concentrations of Al and is therefore a potential important source of dietary Al.³⁵ There is a need to document the variations in clonal tea leaves Al due to plucking standards.

Materials and methods

This study was carried out at the Kenya Agricultural and Livestock Research Organisation – Tea Research Institute located at 0°22'S and

Table 1: Variations of Se (ppm) on the effect of plucking standards on clonal tea

Clone	Plucking standard						Mean clone
	Bud	1 leaf + bud	2 leaves+ bud	3 leaves + bud	4 leaves+ bud	5 leaves + bud	
TRFK 6/8	1.03	0.67	0.56	0.54	0.41	0.51	0.62
TRFK 31/8	1.27	0.70	0.55	0.58	0.42	0.38	0.65
EPK TN14-3	1.15	0.71	0.69	0.36	0.24	0.51	0.61
AHP S15/10	0.59	0.52	0.42	0.32	0.25	0.17	0.38
Mean Plucking Standard	1.01	0.65	0.56	0.45	0.33	0.40	
CV (%)			4.0				13.3
LSD, ($p \leq 0.05$)			0.06				0.05
Interactions ($p \leq 0.05$)			0.12				

Note 1 ppm = 0.001 mg/g or = 1 g/g

35°21'E at an altitude of 2178m amsl. The leaves were obtained from former clonal trial sites planted in 1996, as a randomized complete block design, replicated three times. Plants were under normal estate management,³⁶ but were allowed to grow up to five leaves and a bud plucking level.

Tea leaves were obtained from clones TRFK 6/8, AHP S15/10, TRFK 31/8 and EPK TN 14-3 under a uniform agronomic management system,³⁶ at plucking standards of a bud, 1 leaf and a bud, 2 leaves and a bud, 3 leaves and a bud, 4 leaves and a bud and, 5 leaves and a bud. Approximately 50 g of leaves were obtained per treatment. The samples were oven dried at 80 until they reached constant weight, cooled to room temperature, then ground into powdery to await Se and Al analysis.

Leaf nutrients extraction and determination were done according to the modified AOAC³⁷ official methods. Dry, ground tea leaf (0.25 g) was put in specimen tubes and ashed in a muffle furnace for 4.5 hours at 450°C, or until greyish white ash was obtained. Each ashed sample was cooled to room temperature and digested with 0.5mL of 2:3 double acid of 1:1 HCl (acid to water) and 1:1 HNO₃ (acid to water) mixture. The mixture was evaporated to dryness on a hot plate under low heat and ventilation. The sample was then extracted with 25 mL of 0.05 N HCl for 12 hours, and the extract was diluted by pipetting (0.2 mL) into 25 mL volumetric flask, adding 5 mL of strontium chloride, then set to the mark with distilled water. Diluted extract was analyzed for Se and Al content using a standardized plasma atomic emission spectrophotometer (ICPE-9000, Shimadzu).

Results

The variations of Se levels in young tea leaves due to clones and plucking standards are presented in Table 1. Clonal variations ($p \leq 0.05$) were observed in the Se levels. Clones TRFK 6/8, TRFK 31/8 and EPK TN14-3 had higher levels of Se than clone AHP S15/10. The levels of Se in clones TRFK 6/8, TRFK 31/8 and EPK TN14-3 were, however, not different. The level of Se in the tea leaves varied ($p \leq 0.05$) with plucking s (Table 1). Higher levels of Se were recorded in younger leaves than in older leaves, as Se levels declined with coarse plucking standards in all the clones studied.

The changes in leaf Al levels with clones and plucking standards are presented in Table 2. The Al content varied ($p \leq 0.05$) with clones and increased ($p \leq 0.05$) with coarse plucking standards.

Discussion

Clonal variations in Se levels in different tea cultivars have been observed in China.^{38,39} These results confirm the previous findings⁴⁰ in which there were clonal variations in Se content in samples that were obtained from different locations. The present results show that different clones produced under the same agronomic and environmental conditions have varying abilities to extract selenium from the soil or to partition selenium into different leaves. Supply of Se by tea beverages can therefore be controlled through proper clonal selection programmes. Whereas clones such as TRFK 6/8, TRFK 31/8 and EPK TN14-3 accumulate relatively high levels of Se, clones such as AHP S15/10 do not have such abilities. Clone S15/10 is a unique cultivar that has recorded yields as high as 10,995kg

Table 2: Variations in Leaf Al (%) Contents Due to Clones and Plucking Standards

Clone	Plucking standard						Mean clone
	Bud	1 leaf + bud	2 leaves+ bud	3 leaves + bud	4 leaves+ bud	5 leaves + bud	
TRFK 6/8	0.028	0.040	0.053	0.071	0.081	0.098	0.062
TRFK 31/8	0.025	0.044	0.055	0.057	0.077	0.095	0.059
TN 14-3	0.030	0.061	0.073	0.070	0.089	0.094	0.070
S15/10	0.035	0.044	0.086	0.098	0.117	0.133	0.085
Mean Plucking Standard	0.030	0.047	0.067	0.074	0.091	0.105	
CV (%)			5.9				
LSD, ($p \leq 0.05$)			0.003				0.003
Interactions ($p \leq 0.05$)			0.007				



made tea (mt)/ha/year⁴¹. Other clones usually record yields below 5,000kg mt/ha/year in Kenya.

Although variations had been observed in some tea micronutrients with plucking standards^{22,42}, this is the first report on the effects of plucking standards on tea Se levels. Plucking is an important agronomic activity that affects tea quality.^{23,43,44} and yields.⁴⁴ The results demonstrate that Se levels in tea can be controlled by plucking standards. Fine plucking standards will lead to high levels of Se in tea. The extent/rate of changes in the clonal tea and plucking standards varied in different clones. As a result, there were significant ($p \leq 0.05$) interaction effects between clones and plucking standards. It is therefore not possible to predict how much decline will occur in clonal leaf Se levels based on the determined levels in a particular clone.

In a previous study in Kenya¹⁸, it was speculated without experimental evidence that high levels of Se in tea in Bomet County were predisposing residents to the risk of high incidences of oesophageal cancer. Subsequent reports^{19,45} using tea from Bomet County showed that the selenium levels were within the acceptable range. The FAO/WHO established an upper tolerable limit for selenium of 400 µg/day⁴⁶. For these clones grown under the Kenyan environment, even with very fine plucking standards the upper limit may not be realised.

Clonal variations in aluminum in this study were similar to previous results from India⁴⁷, China⁴⁸, and Malaysia⁴⁹ and Kenya.³⁵ These results demonstrate that different clones of tea expose consumers to different levels of aluminum. Tea is Al accumulator, particularly in the mature old leaves.³⁰ Although Codex Alimentarius Austriacus does not give the limit concentration for aluminum in food and beverages, the permissible daily dose for an adult is 60 mg of aluminum.⁵⁰ Earlier, it was demonstrated that on average, about 30% of aluminum in tea is infused into tea liquors,³⁵ the rest being bound to organic matter,⁵¹ and therefore unavailable for human ingestion in tea drinking. The results presented here demonstrate that plucking even up to 5 leaves and a bud of different tea clones would not expose normal consumers to undesirable levels of aluminum. Drinking tea beverages from different clonal teas may therefore be supplying relatively low amounts of aluminum to human diets. It is concluded that the current recommended tea cultivars and plucking standards in Kenya does not predispose consumers to unacceptable levels of selenium and aluminum. Although significant results have been obtained in the study, there is need to carry out an economic study to determine the most ideal recommendations between plucking standards and different genotypes.

CONCLUSION

Clones produced under the same agronomic and environmental conditions have varying abilities to extract selenium from the soil or to partition selenium into different leaves. Supply of Se by tea beverages can be controlled through clonal selection programmes and controlled plucking standards. Fine plucking standards lead to high levels of Se in tea. The extent/rate of changes in the clonal tea and plucking standards varied in different clones.

Clonal differences were also observed in leaf Al levels. The Al concentrations increased with coarse plucking standards. However, even plucking up to 5 leaves and a bud of different tea clones did not expose normal consumers to undesirable levels of aluminum. Using the current recommended tea cultivars and plucking standards in Kenya does not predispose consumers to unacceptable levels of selenium and aluminum.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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