# Nitrogen and Potassium Fertilizer Residue in Tea Made in Selected Southeast Asian Countries

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**ABSTRACT**

Tea is a processed form of *Camellia sinesis,* which originated from China and has spread throughout the world. Due to increased mass production of tea which leaches soil of its nutrients, additional fertilizers are used as replacements to increase the production yield. The aim of this study is to determine and compare the nitrogen and potassium fertilizer content in tea made in India, China, Cambodia, Sri Lanka and Indonesia. A single sample from each country was tested using Flame photometry and Ultra-violet visible spectrophotometry technique. Results found that the country with the highest percentage of nitrogen present in tea was India at 3.748%, and the country with the highest percentage of potassium in tea was found to be China at 0.983%. Cambodia tea had the lowest percentage of both nitrogen at 2.284% and potassium at 0.930%. Even though China had only 3.580% of nitrogen in their tea they had the highest percentage error of 0.166% which indicated that the nitrogen present was not pure or there might be a mixture of other substances such as pollutants or pesticides. Statistical analysis showed that the content of nitrogen and potassium for China was significantly different compared to other countries at $P<0.01$. Based on the recommended daily intake and the results, the amount of fertilizer content of nitrogen and potassium is acceptable unless the consumer is an excessive tea drinker with underlying renal and liver conditions.

*Keywords: fertilizer, nitrogen, potassium, Southeast Asian Countries, Tea*

## INTRODUCTION

Originating from China, tea and tea planting have spread throughout the world since the middle of the Tang dynasty. Tea is a processed form of the plant *Camellia sinesis* (Figure 1). During the 300 years of the Tang dynasty the tea industry went through rapid development. From the Tang dynasty tea drinking and cultivating spread to many areas of the world including India, Ceylon, the middle east and African countries through trade. Now people from 160 countries in the world are accustomed to tea drinking. The acceptance and affection for tea by people from different countries and different ethnic groups can be largely related to its beneficial effects on health (Chen & Lin, 2015). Tea drinking has become an important constituent of many cultures.

The trademark flavor of tea comes from the considerable amount of natural sugar combined with the bitter phenolic compounds, of that evolved as a defense mechanism to the sweet leaves more unpalatable to animals. This fortuitous interplay between bitter and sweet is what makes tea the most sublime drink (Hinsch 2008).

Tea production is geographically limited to few areas of the world and is highly sensitive to changes in the growing conditions. Tea plants need a hot moist climate, temperatures ranging from 10 to 30-degree Celsius, annual precipitation of 1250mm and preferably acidic soil (CCP 2015).

Many countries are now mass-producing tea to meet with the increase in demand. China has a tea producing area of 2.08 million hectares. Since 2010, China has been the largest tea producer and consumer in the world (FAO 2016). Coming second is India which has a tea production area of 507,007 hectares. Sri Lanka is the third largest producer of tea. While India and China consume most of the tea that it produces, Sri Lanka exports 23% of the world's global demand. Cambodia and Indonesia also cultivate and export large amounts of tea (Sarkar et al. 2016).

There are many different types of tea available for consumption today. The distinguishing factor for the different types of tea is the oxidation level of the leaves. The most popular type of tea is said to be black tea. Black tea undergoes full oxidation till the leaves wither, which intensifies its flavor. In green tea production, the oxidation process is stopped very quickly, and the leaves area only withered slightly (Gardner et al. 2007). Oolong tea undergoes partial oxidation. White tea does not undergo oxidation. They are hand processed using the young shoots of the plant.


*Figure 1. Camellia sinesis (tea plant).*

Tea contains a wide range of compounds that make it beneficial to health. The most important are the flavonoids with polyphenols which is an antioxidant that removes radicles and aids in disease prevention. Another vital substance is catechins that fight against cancer. It also contains fluoride and theanine. Tea drinking has proven to decrease incidence of cardiovascular disease (Chen & Lin, 2015), aid with weight loss, decrease cholesterol and boost immunity. The most commonly consumed type of tea is black tea. In 2016, almost 80% of the tea consumed was black tea (FAO 2016).

However, in the recent years several incidents regarding the adverse effects of tea have been reported. There have been incidents of prolonged or excessive consumption of tea, which has led to hepatotoxicity (Khan & Mukhthar, 2013). Most tea cultivator's use nitrogenous and potassium-based fertilizers. There have been reports of hypokalemic myopathy after excessive drinking of green tea extract.

With the increased mass production of tea, the soil is leached of its nutrients. To maintain productivity these nutrients are replaced by the addition of fertilizers. The nutrients most required by the plants are nitrogen, phosphorus and potassium. Naturally, these nutrients go back to the soil by the decaying plants and animals, but that process takes a much longer duration. Most nitrogen fertilizers come from ammonium sulfate, ammonium nitrate and ammonium phosphate (Cheng et al. 2014). Most potassium fertilizers come from potassium chloride or potassium sulfate. It is very important that the cultivators are properly educated about the implications of using fertilizers and better fertilizer application technology. An alternative to synthetic fertilizers is organic manure.

Most tea producers do follow a set of rules of guidelines to ensure quality of the tea produced and that hygiene is maintained throughout every step of the way. During harvest time plucking of the leaves are done by hand which is a highly labor-intensive method (CPCB 2007). The leaves are checked for bacterial growth and foreign bodies are removed by hand. One of the most important processes of tea production is the oxidation of the leaves. The machines used are cleaned meticulously with hot water to prevent bacterial growth. Bacterial contamination is avoided by washing the drum with hot water or steam. The final process is the packaging of the tea. Packaged tea is analyzed at laboratories for the presence of pesticides and contaminants.

While tea does have a magnitude of health benefits, the increasing cases of tea poisoning and the emerging adverse health effects of tea is a cause for concern. High amount of fertilizers is considered harmful to health, especially if consumed for an extended period. Tea is consumed by people worldwide and the threat that tea contains an unhealthy amount of potassium and nitrogenous fertilizers should not be taken lightly. Proper investigation must be done to address this problem. This research generally aims to evaluate the presence of fertilizer residue in different brands of tea from the countries that are identified as the largest exporters of tea. Specifically, to: 1) determine the quantity of fertilizer content (potassium and nitrogen) in tea made in India, Sri Lanka, Cambodia, Indonesia and China; 2) compare the content of fertilizer present in tea among the five (5) Southeast Asian countries; and 3) identify the country that manufactured tea with the highest residue of potassium and nitrogenous compounds. This information is vital in preventing further health risks due to tea.

## MATERIALS AND METHODS

Research Design

The research was considered a quantitative research, determining the presence of nitrogen and potassium fertilizer residue in tea made in India, Sri Lanka, Indonesia, Cambodia and China.

Sample and Sampling Technique

All tea brands chosen were available in markets and were exported to other countries. The tea chosen for the study originated from the plant *Camellia sinesis* (Figure 1). Black tea was chosen as the type of tea to be tested because it is the most common type of tea to be consumed throughout the world. A random brand of black tea was selected from India, Sri Lanka, China, Indonesia and Cambodia by simple sampling method to decrease bias. A single sample from each country was taken. Total of five brands were tested in this study.

Research Instrument and Techniques

All the samples selected were submitted to Philippine Coconut Authority Laboratory services (Phil CoA) for Flame photometry and Ultraviolet-visible spectrophotometry analysis. The Flame photometry and Ultraviolet–visible spectrophotometry is the method used to determine and compare the content of fertilizer present in tea samples. Flame photometry is a spectroscopic technique used in determining microgram quantities of elements by measuring directly the intensity of their flame produced intensities. This technique remains a simpler, cost-effective and robust technique which is ideally-suited to the quantitative determination of metals that can be easily ionized which are detectable through their characteristic emission spectra (Chu & Taylor, 2016). Flame photometry has been used in several research studies to find the concentration of multiple elements in food materials. Using this method, a study on sodium and potassium content in Brazilian solid dietary sweeteners were determined (Oliveira et al. 2016). The percentage of nitrogen and potassium in tea was determined using flame photometry. Ultraviolet-visible spectrophotometry is a technique that measures the absorption of light across the ultraviolet and visible light wavelengths through a liquid sample. The results were validated to determine the accuracy of the method by using standard reference materials and repeated measurements for each element. The product sample was analysed repeatedly to validate the accuracy of this method (Van Niekerk 2010).

Data Gathering Procedure

Samples were amassed from China, India, Sri Lanka, Indonesia and Cambodia. These countries were selected as they are the foremost tea producer in the world, and export tea globally. Each country varies in geological conditions and has different methods of treating the land with fertilizers before each harvest. The government approved limitation for fertilizer. The content also differs in each country and so does the tea processing and packaging methods.

This study had obtained tea sample from the original manufacturing countries. Experts on tea from each of the countries were contacted and the most popular brand of black tea from each country was selected. This was to prevent any changes to the quality of tea due to inappropriate storage and mishandling during import. The popularity of the tea was checked based on the sales of the tea.

Tea samples were vacuumed packed and sent from each country by the experts. Even though only a single sample of 100g from each country was used in analyzing the fertilizer residue content of

the tea, excess amounts were sent for good measure. Attention was given to the expiration date of the tea. All the tea samples selected had at least six months left for expiration.

The samples were treated with Flame photometry and Ultraviolet–visible spectrophotometry. Simple, accurate and economical methods of finding the chemical composition of tea and non-destructive analytic techniques, which can measure the content of potassium and nitrogenous compounds present in the tea. Samples from each country were analyzed separately. The result from Flame photometry and Ultraviolet–visible spectrophotometry was physiologically measured. The country with the highest content of potassium and nitrogenous compounds were identified. Data from each country was gathered and tabulated for easier analysis and comparisons. The study was cross sectional and analyzed data was collected over a period of 15 days.

Data Analysis

The research utilized descriptive and inferential statistics to answer the research questions. Tests of differences such as Bivariate Correlation of the SPSS was used at $P<0.01$ level of significance to determine the level of potassium and nitrogen fertilizer content in tea produced in India, Sri Lanka, Cambodia, China, and Indonesia.

## RESULTS AND DISCUSSION

The country with the highest percentage of nitrogen present in tea was India (Table 1) and the country with the highest percentage of potassium in tea was found to be China. Cambodia tea had the lowest percentage of both nitrogen and potassium.

*Table 1. Percentage of fertilizer residue in tea made in selected South East Asian Countries.*

| Element | Country | Percentage (%) of element per 100g |
|---|---|---|
| Nitrogen (N) | India | 3.748 ± 0.019 |
| | China | 3.580 ± 0.166 |
| | Sri Lanka | 3.374 ± 0.015 |
| | Indonesia | 3.300 ± 0.042 |
| | Cambodia | 2.284 ± 0.006 |
| Potassium (K) | India | 0.950 ± 0.0001 |
| | China | 0.983 ± 0.0001 |
| | Sri Lanka | 0.955 ± 0.0001 |
| | Indonesia | 0.947 ± 0.0001 |
| | Cambodia | 0.930 ± 0.0001 |

± Indicates error in result

India had a nitrogen content of 3.748%, while Cambodia had 2.284% of nitrogen (Table 1). Indian soil is mostly rich in potash (potassium). To keep mass producing tea, nitrogen fertilizers must be added to the soil and this could be attributed to the high content of nitrogen in Tea for India. In addition, nitrogen rich chemical fertilizers give tea trees a considerable boost (Hinsch 2008). Since

most Cambodian farmers are poor they are unable to afford the cost of inorganic fertilizers which is a major constraint to their use and this prompts promotion of animal manures (Graeme 2014).

Even though China had only 3.580% of nitrogen in their tea they had the highest percentage error of 0.166% (Table 1) which indicated that the nitrogen present was not pure or there might be a mixture of other substances such as pollutants or pesticides. Until the 1950s most of the Chinese tea was organic. Farmers were too poor to afford chemical fertilizers and pesticides, so they enriched the soil in traditional manner with manure, compost and ashes. Economic development has made agricultural chemicals ubiquitous and now very little organic tea is grown. Those who try to adhere to the old farming techniques, face great difficulties as the insects that are native to these sub-tropical regions are difficult to control without pesticides (Omwoyo 2017) and this could be attributed to the percentage error content of nitrogen in tea for China. There is not much incentive for farmers to continue producing organic tea. The flavor and aroma of organic tea is quite insipid. Even the organic farmers admit that their tea does not taste as good as the conventional products. To add to it neither China nor Taiwan has a standard organic certification system. Various government agencies and private groups use widely different criteria to certify food as organic. Since organic tea fetches such a high price, unscrupulous farmers and middle men have considerable financial incentive to pass regular tea as chemical free. China's mammoth cities have the world's worst cases of air pollution and chemical laden smog inevitably drifts into even the most remote mountain regions where it settles on tea trees (Hinsch 2008). Air pollution is extensive in China, with the highest particulate concentration observed south of Beijing, but significant levels extend throughout the interior, which is consistent with previous satellite and modeling estimates. Extensive pollution is not surprising since particulate matter can remain air borne for days to weeks and travel thousands of kilometers (Robert & Richard, 2015). Also, the water quality in China is often substandard, and many farmers have no choice but to use polluted water on the crops. Because tea field is usually quite small, chemical spillover from neighboring plots is quite difficult to control. So even if a farmer adheres to the organic standards, his trees will inevitably absorb some artificial chemical (Hinsch 2008).

The amount of potassium present in China was 0.983% while, Cambodia had only 0.930% (Table 1). According to the statistical analysis of our study, it showed that the content of nitrogen and potassium for China was significantly different compared to India, Sri Lanka, Cambodia and Indonesia at $P<0.01$.

Tea (Figure 1) is an essential beverage that quenches the collective thirst of millions of people every day (Heiss & Heiss, 2010). Tea is one of the few beverages that people sip on throughout the day. However, prolonged and excessive consumption of tea has a negative impact on the health of the consumer. A case of iced tea induced nephropathy was reported in the United States in 2014 (Syed et al. 2015). A study conducted in Italy in 2015 reviewed nineteen cases of hepatotoxicity linked to the intake of herbal products containing green tea, from the year 2008 to 2015 (Mazzanti et al. 2015). From these incidences it is evident that excessive consumption of tea, especially by those who already have underlying renal and liver conditions may be harmful due to the residue content of nitrogen and potassium in the tea.

The results of this study have implications for potential positive changes in the field of tea agriculture, in policy level, production level, as well as consumer level. At policy level, implication in improving the agricultural, export and import guidelines that are currently been followed. It serves as a push towards strict enforcement of rules and regulations during farming and production

of tea. Establishment of a universal guideline for the content of fertilizers is necessary at this junction. It provides essential information regarding the components found in tea and how it can affect their health and wellbeing to the numerous tea consumers around the world. It also sheds light on the consequences of prolonged and excessive tea drinking. So, the consumers know the constituents of tea as well as significance of abuse of tea drinking. It acts as eye opener for tea farmers about the consequences of negligent use of fertilizers. It also emphasizes on the importance of hygiene maintenance in the production process to prevent the contamination of tea. Aside from that, it can also encourage farmers to come up with a better production method to decrease the content of fertilizers that ultimately ends up in their packaged goods.

## CONCLUSIONS

The study concluded that minimal residue of potassium and nitrogen fertilizer was present in tea made in India, China, Indonesia, Sri Lanka and Cambodia. Based on the recommended daily intake and the results of this study, the amount of fertilizer content of nitrogen and potassium was acceptable unless the consumer is an excessive tea drinker with underlying renal and liver conditions. Among these countries, tea made in India had the highest percentage of nitrogen residue at 3.748% and tea made in China had the highest percentage in potassium residue at 0.983%. Cambodia had the least amount of nitrogen and potassium fertilizer residue at 2.284% and 0.930%, respectively. According to the statistical analysis of our study, it showed that the content of nitrogen and potassium for China was significantly different compared to India, Sri Lanka, Cambodia and Indonesia at $p<0.01$.

## RECOMMENDATIONS

Using larger sample size, testing for other organic and inorganic substances used in fertilizers is recommended. This research has only investigated the potassium and nitrogen fertilizer residue present in commercially successful brands of tea from five countries. Further studies on farming techniques in relation to environmental conditions are required to establish the validity of the claim that fertilizer residue in mass produced tea is in fact due to difference in farming techniques or environmental condition. More studies should focus on prolonged tea drinking needs to be carried out, to find out whether it influences human health. Studies concentrating on the correlation between drinking tea with fertilizer residues and its effect on health can also be carried out.

## REFERENCES


Chen, Z., & Lin, Z. (2015). Tea and human health: Biomedical components of tea active components and current issues. *Chinese Academy of Agricultural Science*, 87-102.

Cheng, H., Shuang-lai, L., Tan, Q., Dong-Hai, L., & Yun-Feng, C. (2014). Effects of 30 years repeated fertilizer applications on soil properties, microbes and crop yields in rice-wheat cropping systems.

Chu, H., & Taylor, S. (2016). An experimental demonstration of a multi-element flame photometer: Determination of salt concentration in soy sauce. *International Journal of Chemistry,* 8, 25-31.

Commitee on Commodity Problems. (2016). Current situation of tea production and marketing in China. *Navivasha: Food and Agriculture Association of the United Nations.*

Food and Agriculture Organization of United Nations. (2016). Report of the working group on global tea market analysis and promotion.

Gardner, E., Ruxton, C., & Leeds, A. (2007). Black tea – helpful or harmful? A review of the evidence. *European Journal of Clinical Nutrition,* 61, 3-18.

Graeme, B. (2014). Nutrient status of cambodian soils, rationalisation of fertiliser recommendations and the challenges ahead for Cambodian soil science. *Australia: University of New England*.

Heiss, M., & Heiss, R. (2010). The tea enthusiast's handbook. *New York: Crown Publishing Group*.

Hinsch, B. (2008). The Ultimate Guide to Chinese Tea. *Bangkok : White Lotus Press.*

Khan, N., & Mukhthar, H. (2013). Tea and Health: Studies in Human. *Current Pharmaceutical Design*.

Mazzanti, G., Di Sotto, A., & Vitalone, A. (2015). Hepatotoxicity of green tea: an update. *Archive of Toxicology,* 89(8): 1175-1191.

Oliveira, AP., Martins, DL., Martins, ML., & Villa, RD. (2016). Determination of Na and K in Brazilian solid dietary sweeteners by flame photometry. *International Food Research Journal,* 23(5): 2203-2206.

Omwoyo, WN. (2017). Effects of nitrogenous fertilizer rates, plucking intervals and geographical location of production on selected micronutrient levels of the black tea. *Journal of Tea Science Research*.

Robert, A., & Richard, A. (2015). *Air pollution in China: Mapping of concentrations and sources.* California: University of California.

Sarkar, S., Chowdhury, A., & Das, S.(2016). Major tea processing practices in India. *International Journal of Bioassays,* 5, 5071.

Syed, F., Menna-Guitierrez, A., & Ghaffar, U. (2015). A case of iced-tea nephropathy. *The New England Journal of Medicine*, 1377-1378.

The Central Pollution Control Board . (2007). Comprehensive industry document on tea processing industry. *India: Ministry of Environment & Forests* .

Van Niekerk, F. (2010). Method development and validation for the analysis of silicon, phosphorus, sulphur, chromium and metal oxides in charge chrome Ferro-Alloy by X-Ray Fluorescence Spectroscopy. 53-55.