

Research Article

Gamma Spectrometry Study of Radioactivity in Some Types of Teas on the Local Ivorian Market

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Abstract

Radioactivity is a natural phenomenon present in the environment in which we are permanently present. Thus, due to its presence in soil and water and its absorption by plants, radioactivity is found in foodstuffs such as tea. The latter comes from a tree, the tea plant, which is highly sensitive and vulnerable to climatic conditions. When infused, this tea drink, which is very common in Ivorian homes, is therefore likely to be a vector of radioactive contamination of the population. The objective of this work is to identify the presence of radionuclides in tea, evaluate their activity according to the duration of infusion and their impact on the health of consumers in order to develop a consumption methodology. During this study, six different brands of teas that are quite popular were collected on the local Ivorian market and infused in water. After analysis by the gamma spectrometry method, we were able to determine the specific activities of the radioelements detected in the brewed teas. The most abundant radioactive elements are Th232, U238, U235 and the activity values obtained are well below those recommended by UNSCEAR and the ICRP. These results tend to show that the Ivorian population is not at risk of consuming the tea within the preparation times recommended by the manufacturer, which are less than or equal to five (5) minutes.

Keywords

Radioactivity Teas, Gamma Spectrometry, Ivorian Local Market

1. Introduction

Like ordinary water, tea is a widely consumed beverage in the world, for its many virtues. However, a study on radioactivity in food shows that the activity in tea is very high [1]. Radioactivity is an integral part of the physical environment. According to the National Council for Radiation Protection and Measurements (NCRP), environmental radiation is the most important source of radiation exposure for humans.

Interestingly, although the International Atomic Energy Agency (IAEA) has reported that public exposure to natural radiation is of little health concern, the World Nuclear Association (WNA) states that any dose of radiation involves a possible risk to human health [2]. Uranium-238 U, 232Th, and 40 K occurring individually are the most abundant radionuclides found naturally in soil, air, water, rocks, plants, and

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foodstuffs [3]. To protect the public from undesirable exposures to natural and artificial radiation, radioactivity in environmental samples, including foodstuffs, must be monitored periodically. The general objective of this study is therefore to evaluate the level of radionuclides in tea samples collected on the local Ivorian market in order to develop a methodology for their consumption and infusion.

MATERIAL AND METHOD Material This study was conducted in the laboratory of the Cote d'Ivoire Radiation Protection and Security Authority, abbreviated ARSN. The equipment used in this work is a gamma-ray spectrometer from the said laboratory. A gamma-ray spectrometer (GRS) is an advanced device for measuring the energy distribution of gamma radiation, especially for gamma rays with energies greater than several hundred keV [4]. In general, all the elements that make up a gamma spectrometry chain must have the property of linearity, i.e. contribute to the proportionality between the energy given up and the final momentum obtained [5]. The canberra gamma spectrometry chain consists of the following equipment [6]: a detector protected by lead shielding, a preamplifier, an amplifier, a multi-channel analyzer, a cooling system, as well as a high-performance computer. with software dedicated to data processing. To work, the detector must be polarized by a high-voltage power supply. The signal from the detector must be shaped by a preamplifier to then be usable in the whole of the measurement chain (Figure 1). The purpose of this chain is to connect the electrical signal to an energy and then to count the different energies obtained.

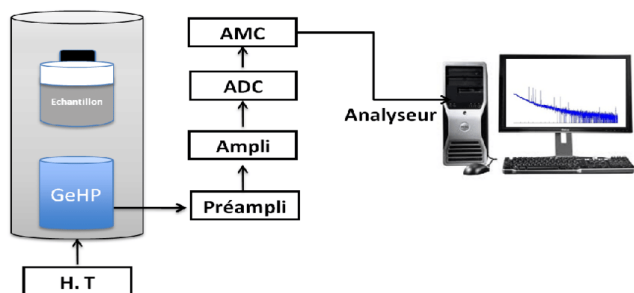


Figure 1. Simplified diagram of a gamma spectrometry chain [7].

Method For the choice of the different teas used in this study, several criteria prevailed: - a survey in some neighborhoods of the city of Abidjan to determine the slimming teas most consumed by the said population; - a local observation of teas widely consumed by different social strata on the Ivorian market; - Finally, because of its relaxing, soothing qualities, refined taste and especially their presence and use by the wealthy classes, certain teas have been chosen. - A total of six (6) different teas were chosen. These are Longrich slimming tea, Lipton teas (black and green), Olinda tea (black), Achoura tea (green) and verben. The teas selected have been coded in accordance with the table below.

Table 1. List of selected and codified teas.

Tea	Type of teas	Code
Lipton	Black	TNLI
	Green	TVLI
Olinda	Black	TNO
Achoura	Green	TVACH
Longrich	Green	TVLO
Verveine	-	TVER

The elements present in tea including radioelements, are related to the minerals present in the plant. When brewing, water, hot or warm, helps to extract the dissolved elements in the tea leaves. The concentration of radioelements in a tea infusion can therefore be influenced by the infusion time, but this relationship depends on several factors (water temperature, type of tea, etc.). This study focused on brewing time. The infusion times used are recorded in the following table:

Table 2. Brewing time of different tea samples.

Tea	Brewing times (mn)		
	Manufacturer's Recommended Time	Average survey time	Maximum survey time
TVLI	2	10	60
TNLI	3	10	60
TNO	4	10	60
TVER	5	10	60
TVLO	5	15	60

Then, to determine the quantity of tea to be brewed by Marinelli geometry, we placed ourselves in the real conditions of consumption by the population and also in the conditions recommended by the manufacturers, i.e. one tea bag per cup. This came down to two cups for a 500ml Marinelli geometry. In general, the identical brewing protocol for all teas except Ashura green tea is as follows, based on the principle of one tea bag per cup for brewing:

-Boil water at the indicated temperature; - Spill hot water into the Marinelli geometry to the necessary volume - Brew the two bags of each tea according to the times indicated in the table above: -Remove tea bags; -Hermetically close the geometry; -Let cool for at least 21 days; - Put to analysis by gamma spectrometry.

As far as Ashura green tea is concerned, due to the

presentation of the product, the only difference in the infusion protocol adopted is that a mass of 25 grams is used unlike other teas which are packaged in bags. At the end of the various infusion times, the Ashura tea leaves are removed. The gamma spectrometry method was used to determine the radioactive activities contained in each sample. This technique has been calibrated in terms of energy and efficiency beforehand, in order to free our measurements from error and make them reliable [8].

2. Results

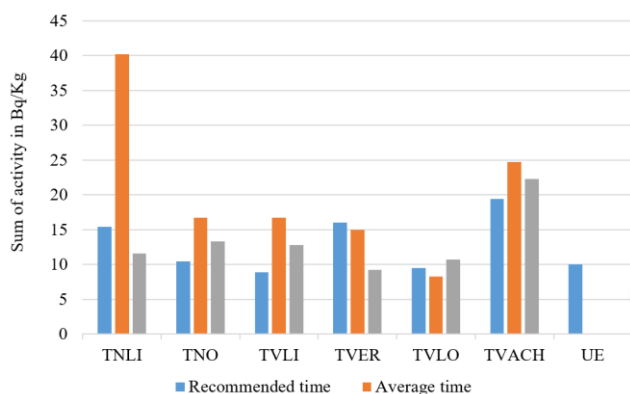


Figure 2. Total specific activity of brewed teas as a fonction of brewing times.

The total activities of radionuclides in the different tea beverages vary from 8.91 ± 0.76 Bq/Kg to 19.45 ± 1.29 Bq/Kg at the infusion times recommended by the manufacturers, then from 8.27 ± 0.68 Bq/Kg to 40.18 ± 5.26 Bq/Kg at the mean infusion times and finally from 9.24 ± 0.71 Bq/Kg to 22.33 ± 2.29 Bq/Kg at the maximum infusion time. The maximum recommended radioactive activity value in tea beverages is 10 Bq/Kg [9].

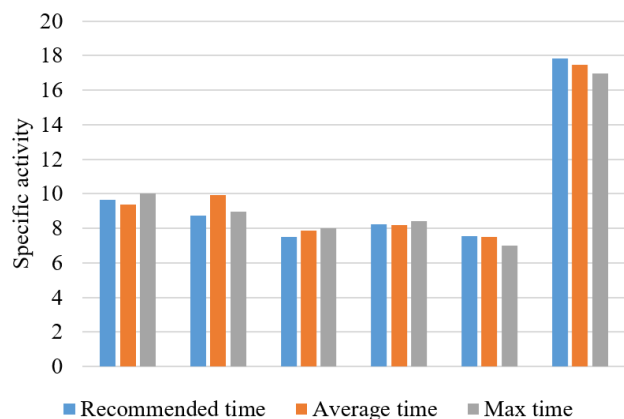


Figure 3. Specific activity of K-40 in brewed teas as a function of brewing times.

The activities of K-40 in tea beverages are constant during the 3 different brewing times (From 7.00 ± 0.6 Bq/Kg to 9.94 ± 0.69 Bq/Kg) with the exception of the TVACH where they vary from 16.96 ± 1.00 Bq/Kg to 17.82 ± 1.02 Bq/Kg.

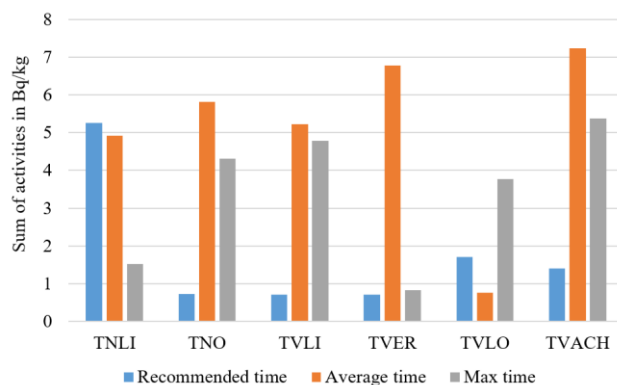


Figure 4. Total activities of the U-238 family in brewed teas.

The total activities of radioelements from the U-238 family in brewed teas vary from 0.7 Bq/Kg to 5.26 Bq/Kg at the recommended infusion times, then from 0.75 Bq/Kg to 7.24 Bq/Kg at the mean infusion times and finally from 0.82 Bq/Kg to 5.37 Bq/Kg at the maximum infusion times. Elements of the U-238 family are present in small quantities in the various teas brewed at the recommended infusion time, except in TNLI tea.

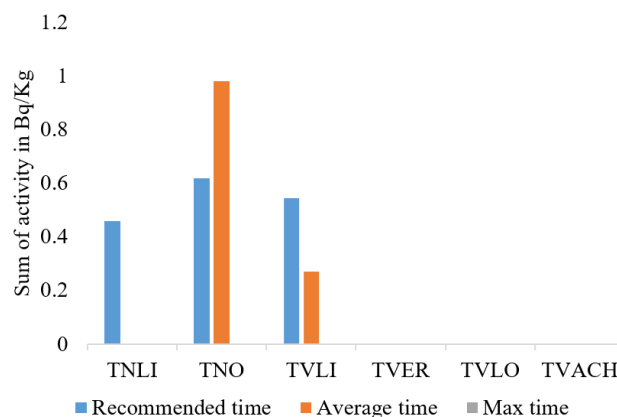


Figure 5. Total activities of the Th-232 family in brewed teas.

The activities of radionuclides from the Th-232 family are very low in tea infusions. They vary from 0.27 Bq/Kg to 0.98 Bq/Kg. They are only found in TNLI, TNO, TVLI teas and only at recommended and medium brewing times.

The specific activities of U-235 in brewed teas were found to be very low. They range from 0.08 Bq/Kg to 0.39 Bq/Kg. U-235 is only present in the various tea drinks at the infusion times recommended by the manufacturers, with the exception of TNLI tea where it is present at the maximum infusion time.

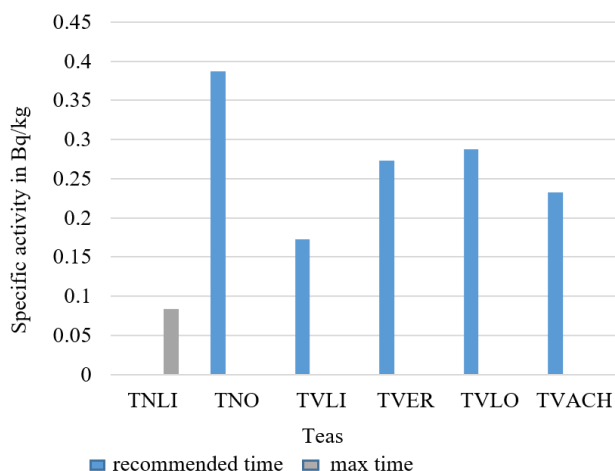


Figure 6. Total activities of the U-235 family in brewed teas.

3. Discussion

In this study, we were looking at 6 different brands of teas brewed at 3 strokes each. The specific activities of radionuclides decrease considerably from the raw tea bag to the tea beverage for all brands analyzed and then vary with the brewing time. This decrease could be explained by the retention of a quantity of radionuclide during the infusion of teas. μ

This means that there is a good time to brew the teas we consume. These different variations could be due to the melting of the elements detected, the quality of the teas, and also the quality of the filter papers used for the infusion of teas, also known as "tea bags".

K-40 is the most abundant radioelement found in brewed teas as shown in Figure 3 compared to Figures 4, 5, 6. This could be explained by the high amount of K-40 in non-brewed teas and also because of its melting temperature of 64 °C. Indeed, with a temperature of about 95 °C to 100 °C, the water used for the infusion of the teas facilitates the fusion of the radioelements of K-40 during the various infusions.

The specific activities of radionuclides in samples of brewed teas are generally lower at the manufacturer's recommended infusion times and at the maximum than at the average infusion times according to Figure 2. In addition to this, the activity decreases from the average brewing time to the maximum brewing time for all brands of teas studied except in TVLO tea.

These observations could be explained by the fact that at the times recommended by the manufacturers (relatively low) the radioelements do not have enough time to allow the dissolution of a large quantity in tea drinks, by the disappearance of certain radionuclides at the maximum infusion time. Indeed, from a relatively long time, these radionuclides in contact with hot water react chemically to form new bodies that are often volatile. Indeed, in aqueous solution, the oxides formed are likely to complex with different ligands to form new non-radioactive bodies.

The specific activities found in most teas brewed at the

average brewing time are generally the highest compared to those detected at other brewing times because at this time (from 10 to 30 minutes) the radioelements present in them have more time to dissolve in the drink; Beyond that, some radioelements oxidize very quickly in the presence of oxygen and this property could promote the appearance of other radionuclides often masked in tea not brewed at this said brewing time.

This is the case of TnLI tea, which records the highest amount of specific activity in the beverage obtained at the average brewing time. Indeed, it is important to note the presence of an artificial radioelement: Am-241 appeared at the average infusion time with an activity of about 25 Bq/Kg; while the limit recommended by the European Union is set at 20 Bq/Kg in tea infusions [10]. This could be explained by the physicochemical properties of Am-241, which oxidizes rapidly in the presence of oxygen [11]. Indeed, given the high radiotoxicity of Am-241, the abnormal amount of this artificial radioelement detected in TnLI tea brewed at the average time could be harmful to the health of consumers and be the basis of several diseases [12]. It should be noted that the values of the specific activities obtained in teas brewed at the recommended times are all below the values recommended by UNSCEAR [13] except in the TnLI and TVER. Am-241 were also all higher in teas brewed at the mean time except in TVLO, and were found above the values recommended by UNSCEAR [14] in teas brewed at the maximum time except in TVER and TVLO teas. Of the 6 brands of teas studies, TVACH is the only tea whose specific activities contained in the different infusions are all higher than the values recommended by UNSCEAR estimated at (10Bq/Kg) [15] While TVLO is the one whose quantity of activity present at the 3 different infusion times is less than or approximately equal to the limit of radioactivity allowed in a tea drink. Regarding the TVACH, this observation could be explained by the absence of tea bags during infusions. Indeed, during the infusions of Ashura green teas, the raw tea leaves are in direct contact with the water used. This could reduce the retention rate of radioelements during the transfer of radionuclides from the powder to the TVACH drink. The quality of TVACH tea, could also be a cause. For TVLO, the activity present at the 3 different infusion times is less than or approximately equal to the limit of radioactivity allowed in a tea beverage could be explained by the fact that this tea records the lowest amount of K-40 transfer from the powder to the different beverages obtained with each infusion. The work presented is devoted to the study of radioactivity in samples of tea beverages collected on the local market in Côte d'Ivoire. The study was carried out on six different brands of teas: Lipton black tea, olinda black tea, Lipton green tea, verbena tea, Longrich green tea and Ashura green tea. In order to assess the radioactivity of these samples, they were sealed with tape for a period of at least 21 days in order to reach secular equilibrium and then placed in the presence of the gamma spectrometer at the Radiation Protection, Safety and Nuclear Safety Authority ARSN. The analy-

sis of the samples revealed the presence of essentially naturally occurring radionuclides and determined the specific associated activities. However, the measured values are all below the recommended limit values for dried tea drinks.

4. Conclusion

The work presented is devoted to the study of radioactivity in samples of tea beverages collected on the local market in Côte d'Ivoire. The study was carried out on six different brands of teas: Lipton black tea, olinda black tea, Lipton green tea, verbenia tea, Longrich green tea and Ashura green tea. In order to assess the radioactivity of these samples, they were sealed with tape for a period of at least 21 days in order to reach secular equilibrium and then placed in the presence of the gamma spectrometer at the Radiation Protection, Safety and Nuclear Safety Authority (ARSN). The analysis of the samples revealed the presence of essentially naturally occurring radionuclides and determined the specific associated activities. However, the measured values are all below the recommended limit values for dried tea drinks.

Abbreviations

UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
ICRP	International Commission of Radiation Protection
Bq/Kg	Becquerel per Kilogramm

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Author Contributions

Konate Issa: Conceptualization, Writing, Ressources
Gogon Bogbédouo Louis Huberson: Supervision, Data curation

Kouakou Melina, Tryphose: Investigation, Methodology
Oka N'Guessan Guy Leopold: Formal Analysis, software

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography



Konate Issa is an assistant professor and lecturer at University Félix Houphouët Boigny (UFHB) of Abidjan, Sciences of Structure of Matter and Technology (SSMT) Training and Research Unit. He is a permanent member of the Physics Department, Laboratory of Sciences of Matter, Environment and Solar Energy, Nuclear Energy and Radiation Protection team. He acquired his Doctorate in Nuclear Physics from University of Abidjan (now UFHB) in 2018. Since 2019, he is teaching different courses (Nuclear Physics, mechanic, electricity etc.) at UFHB. He is actually an Associate Professor, and he's been the advisor of many students during their Master of Nuclear Sciences and Techniques in the same institution in Côte d'Ivoire. He is the author of several publications in different research

fields.



Oka N'Guessan Guy Leopold is a nuclear physicist by training and a Qualified Expert in Radiation Protection. He is currently the Deputy Director of Nuclear Safety and Security of the Radiation Protection, Nuclear Safety and Security Authority (ARSN, Regulatory Body for Nuclear Safety and Security of Côte d'Ivoire) and Sworn Inspector of ARSN. He is also a Research Associate at the Laboratory of Nuclear Energy and Radiation Protection of the Institute for Research on New Energies of the University of Nangui-Abrogoua. He was Head of Radiation Protection Services at the Sub-Directorate of Protection against Ionizing Radiation (SDPRI) of the National Public Health Laboratory (LNSP) from 2002 to 2008 and then Manager of the "Radiation Protection and Environment Consulting" consultancy from 2009 to 2013.



Melina Tryphose Kouakou is a dedicated and driven Medical Physicist student at the International Center for Theoretical Physics (ICTP). She holds a Master's degree in Nuclear Physics and Radiation protection from University Félix Houphouët Boigny of Abidjan (UFHB); Showcasing her deep expertise in the field of physics and its applications in healthcare.



Gogon Bogbédouo Louis Huberson is a lecturer (Associate Professor) at the Felix HOUPHOUT-BOIGNY University of Abidjan, at the Sciences of Structure of Matter and Technology (SSMT) Training and Research Unit. He is a permanent member of the Physics Nuclear and Radiation Protection team which is under the Laboratory of Sciences of Matter, Environment and Solar Energy. He got his Doctorate in Nuclear techniques and Physics from the Caddi Ayad University at the Semailia Faculty of Sciences in Marrakech (Morocco) in 2010. He is teaching different courses related to physics at UFHB. As an Associate Professor since 2022, he supervised several master theses of Nuclear Sciences and Techniques. He got a AIEA Post Graduate Educational Course in radiation protection and the Safety of Radiation Sources (PGEC) in March 2014. He is also a Deputy Director of Authorization of the Côte d'Ivoire's Regulatory Body for Nuclear Safety and Security (ARSN) and the sworn inspector of this regulator.

Research Field

Konate Issa: Determination of DRL for thorax and lumbar spine exam, study of optimization of doses, doses in mammography, radioactivity in tap water, radioactivity in road dust, activity of radon in the basement of building, radioactivity in teas.

Oka N'guessan: Evaluation of the radiological quality of drinking waters and certain foods commonly consumed in households in Côte d'Ivoire, study of optimization of doses.

Melina Triphose Kouakou: Showcasing her deep expertise in the field of physics and its applications in healthcare, Evaluation of the radiological quality in teas.

Gogon Bogbédouo Louis Huberson: radioecology or environment, radiological physics, modelization and simulation, Radiation Protection, Nuclear safety and security.