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Original article

Analysis of the concentration of gamma-emitting radioisotopes in marine fish samples

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Abstract. Marine fish products (fish) represent an important source of nutrition for all mankind. In the food pyramid, fish products are located in the highest levels and therefore may absorb chemical pollutants and isotopes, thus transferring them to humans. The aim of the work was to verify the presence of gamma-emitting isotopes (^{131}I, ^{137}Cs, ^{210}Pb) in a random sample consisting of 12 species of marine fish regularly caught in the oceans. The results demonstrate that there is no significant radioisotope pollution in the small sample analysed. However, the possible presence of isotopes in the marine environment should be monitored given that there are powerful nuclear weapons in the world and many ongoing conflicts.

Key words: radioisotopes, fish, pollution, environment

Introduction and purpose

Among the most important foods in the world population are marine products, in particular fish (1,2). The consumption of marine fish products has increased over the years and this is due, in addition to a culinary tradition, also to the nutritional benefits that this type of food brings. In fact, the content of Omega 3 fatty acids is important in fish, but the amount of protein is also on average high, while the amount of saturated fatty acids is on average low (3). The protein quality in marine fish has a high biological value, providing human nutrition with all essential and non-essential amino acids. Despite this, there are several pollutants that have paid attention to the processes of bio-accumulation of harmful substances, including radioisotopes (4,5). Isotopes are defined as those nuclei having the same atomic number (protons) but different number of neutrons (therefore different mass number). Radioisotopes are radioactive isotopes, i.e. unstable nuclides which decay spontaneously or induced, emitting energy in the form of radiation, until stability is reached.

Radioactive pollution may contaminate soil and water both in a natural way, through radioisotopes present in the earth's crust, and in an artificial way, following first the nuclear tests and the explosions in Hiroshima and Nagasaki, and then the peaceful use of nuclear energy and related accidents (e.g. Chernobyl or Fukushima).

A natural radioactive element of primordial origin is uranium, the extraction of which takes place in many areas of the world and is dangerous due to the quantity of radioactivity emitted (6). Uranium may enter water, soil and air, thus contaminating plants, fish, animals and consequently the food consumed by man. Lead-210 (^{210}Pb), Polonium-210 (^{210}Po) and Radium-226 (^{226}Ra) are the most important products of the decay process of Uranium-238 (^{238}U). ^{210}Po and ^{210}Pb are known as reactive radioisotopes in the marine environment, in fact ^{210}Po is absorbed by plankton and organic particles while ^{210}Pb is absorbed by inorganic particles of the sea (7,8).

A radioactive substance of artificial origin is Cesium-137 (^{137}Cs), a cation which can accumulate in the fillet of numerous fish species. The half-life (time it takes for the number of radioactive atoms to decrease to half of the initial value) of ^{137}Cs is very high, and this increases the risk of accumulation in the environment. Another artificial radioisotope is Iodine-131 (^{131}I), obtained by fission of Uranium-235 in a nuclear reactor and used for medical purposes (therapy of hyperthyroidism and treatment of thyroid cancer). It may be metabolized in seaweed which is rich in iodine.

The aim of the work is to analyze the possible presence of gamma-emitting isotopes in various marine fish, fished regularly according to the provisions of the law.

Materials and methods

Each radioisotope can be identified by measuring its half-life and the energy of the radiation it emits. Below are the main characteristics of the gamma-emitting radioisotopes of interest (9) (Table 1).

In order to evaluate the individual emissions of the isotopes indicated above, the gamma spectrum from 15 to 2000 keV was analyzed using a PerkinElmer Gamma Counter Cobra II Auto Gamma Packard. The identification of ^{210}Po and ^{226}Ra is not possible with the supplied instrumentation as they are pure alpha emitters, with a gamma percentage intensity close to zero. 12 samples taken from different marine fish species in various parts of the oceans were analyzed (Table 2). An empty sample was also counted to obtain the environmental background value, which was subtracted from each measurement of the samples analyzed in order to obtain the net cpm (counts per minute). An example of the spectrum obtained for the different samples and for the environmental background is shown in Figure 1, where the cpm are shown on the ordinates while the emission energies (keV) from 15 to 2000 keV are shown on the abscissas (acquisition window). The counting time for each sampling was 600 minutes, so as to allow good counting statistics and therefore greater measurement accuracy. The sensitivity of the instrument makes it possible to measure low values of activity concentration, of the order of tens of Bq/litre (1 Bequerel = 1 disintegration/second), thus being able to detect even small quantities of radioactivity, if present. Furthermore, the analysis of the gamma emissions of ^{137}Cs alone was performed, setting the acquisition energy window between 600 and 700 keV.

Results

The gamma spectrum obtained for all the samples analyzed revealed the absence of radioactive isotopes in significant quantities (Figure 1 and Figure 2). The values obtained in terms of cpm are, in fact, similar to the value of the environmental fund obtained ("FUND" in Table 2). Also, with regard to the single emission of ^{137}Cs there is no significant difference with respect to the value of the environmental background. This

Table 1. Main characteristics of radioisotopes gamma emitting.

ISOTOPE	HALF-LIFE	DECAY TYPE AND INTENSITY %	EMISSION RANGE (energy and intensity %)
^{131}I	8.02 days	β^- (100%)	364.489 keV (81.5%)
^{137}Cs	30.08 years	β^- (100%)	661.657 keV (85.1%)
^{210}Pb	22.2 years	β^- (100%); α ($1.9*10^{-6}$ %)	10.8 keV (22.7%) 46.539 (4.25%)

Table 2. Marine fish samples.

n° Sample	Sample	Fished Place	Sample weight gr	Spectrum gamma window 15-2000 KeV: (cpm)	^{137}Cs window 600-730 KeV: (cpm)
	FUND			334	26,3
1	Tuna in oil	East central Atlantic	1,034	334	26,5
2	Atlantic cod fillets	South West Atlantic Ocean FA041	1,239	335	26,3
3	Fillets hake (Merluccius Capensis)	South East Atlantic FAO47	1,858	334	26,6
4	Mackerel fillets	Atlantic Ocean	0,856	335	26,3
5	Southern Hake (Macruronus Novazelandlae)	Ocean Pacific South/West	0,967	334	26,7
6	Pacific hake (Merluccius Products)	Ocean Pacific North/East	1,391	334	26,5
7	Wild Salmon (Oncorhyinchus Gorbuscha)	Ocean North West Pacific	1,113	337	26,6
8	Sardine Fillets	Eastern Central Atlantic	0,771	333	25,5
9	Atlantic cod fillets (1)	South West Atlantic	0,981	342	26
10	Atlantic cod fillets (2)	South West Atlantic FAO41	1,023	337	25,9
11	South African hake (merluccius capensis)	South East Atlantic FAO47	1,035	334	26,3
12	South African cod fillets	South East Atlantic FAO47	1,038	332	25,8

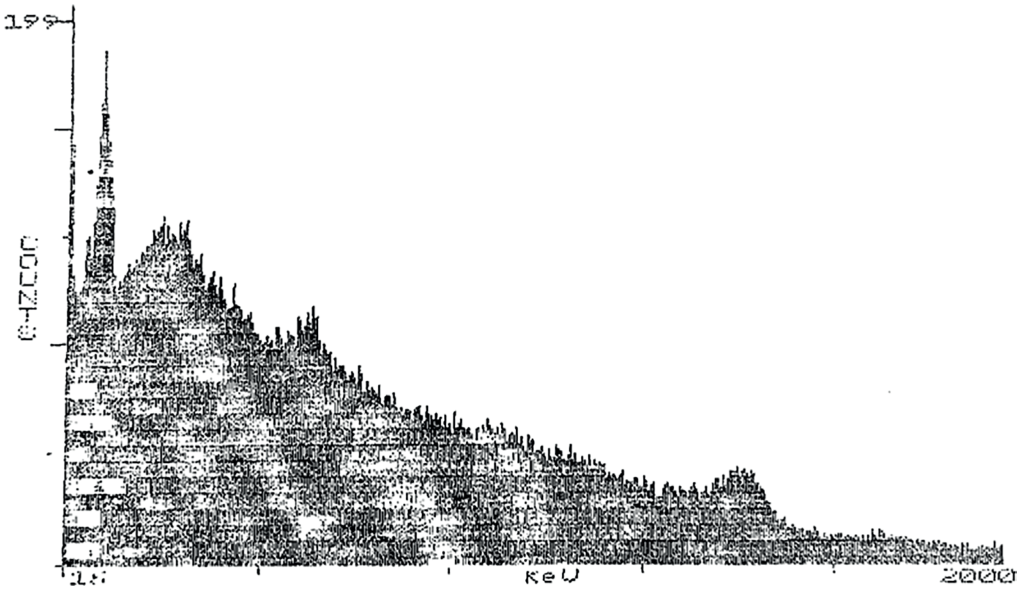

Figure 1. Spectrum of the environmental background.

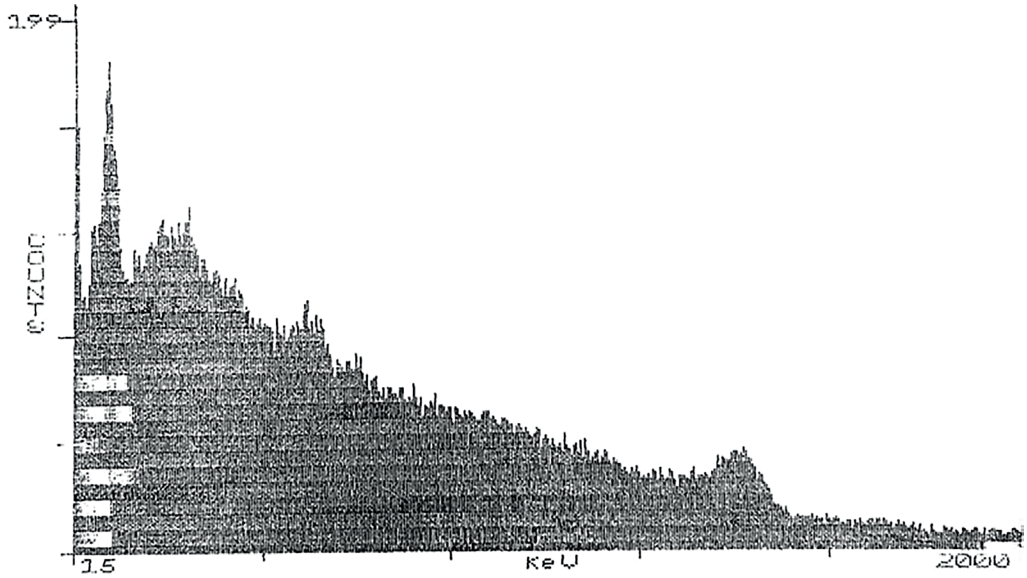

Figure 2. Spectrum of sample n. 2.

demonstrates the absence of significant concentrations of radioactive isotopes in all 12 samples analysed.

Conclusions

Although the sample is not numerous, the fish analyzed are all of medium/large size. These therefore represent the top in the food chain and absorb various pollutants including the radioisotopes described, starting from zooplankton and small fish and sea clams. The radioisotopes described above mainly come from human activities, i.e. from nuclear tests, waste from medical activities (nuclear medicine as regards ^{131}I), from accidents at nuclear power plants such as Chernobyl and Fukushima (5) and from nuclear wars. Furthermore, given that some radioisotopes have a very long half-life, they may remain in the environment for millions of years and therefore may enter the human body through the food cycle, thus threatening the life of organisms especially when they are present in appreciable quantities, emitting harmful and dangerous rays. The data obtained, even with the statistical limit, demonstrates that the radioisotopes analyzed are not present in measurable quantities in the fish samples analyzed and therefore completely safe for human health. This does not mean that we can be calm for the future especially since in many parts of the world wars are underway and the nuclear threat from conflicts and disasters from centrals nuclear is unfortunately always present. It is necessary that men realize more and more the absurdity of the use of atomic weapons. Therefore, it is desirable to periodically carry out the above analyzes to monitor radioisotope pollution in the marine environment, in order to ensure such an important source of nutrition for men and to increasingly safeguard the earth and the oceans which are the environments in which we live.

References

1. Bolek S Food purchasing, preservation, and eating behavior during COVID-19 pandemic: a consumer analysis. Ital J Fodd Sci. 2021 ,33:14-24 doi: 10.15586/ijfs.v33i3.2048.
2. Wang J-L, Zhao F, Cairang Z-M, Li X-Y, Kong J, Zeng S-Y et al. Correlation between the bacterial community nd flavour of fermented fish. Qual Assur Saf Crops Foods 2021, 13:82-91.
3. Tuzen M, Soylak M. Determination of trace metals in canned fish marketed in Turkey. Food Chem 2007, 101:1378-1382.
4. Zalewska T, Suplinska M. Fish pollution with anthropogenic 137Cs in the southern Baltic Sea. Chemosphere 2013 90:1760-1766.

5. Sirin M. Investigation of accumulation of radionuclides in different tissues of Whiting fish (Merlangius, merlangus eusinus Nordmann, 1840) caught on the coasts of Rize in the eastern Black Sea region of Turkey. Microchem J. 2020 152:1043-49.
6. Skipperud L, Jørgensen AG, Heier LS, Salbu B, Rosseland BO. Po-210 and Pb-210 in water and fish from Taboshar uranium mining Pit Lake, Tajikistan. J Environ Radioact. 2013 Sep;123:82-9. doi: 10.1016/j.jenvrad.2012.03.013.
7. Akozcan S, Ugur A. Activity levels of 210 Po and 210 Pb in some fish species of the Izmir Bay (Aegean Sea). Mar Pollut Bull.2013 66:234-238 doi:10.1016/j .marpolbul.2012.10.003
8. Tahir SN, Alaamer AS, Ayub M, Khan MZ. Radiometric analysis of samples of domestic fish species and radiological implications. Health Phys. 2010 May;98(5):741-4. doi: 10.1097/HP.0b013e3181d18f4a.
9. Nationa Nuclear Data Center, Brookhaven National Laboratory - https://www.nndc.bnl.gov/ (verified on 17-08-2023).

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