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P2_8 How radioactive is a banana?

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Abstract

This paper assesses how radioactive a banana is and whether this is harmful. It is found that only a small percent of the total potassium in a banana is radioactive, and this small percent poses absolutely no risk to a person. It is found that a person would have to consume over 37 billion bananas to cause any risk of death, and that even surrounded by bananas, it would take over a billion to cause any harm.

Introduction

Potassium is an essential element for humans to consume. Potassium is used for a plethora of things, from regulating blood pressure and bone mass to sustaining the nervous system and muscle function[1]. It is no surprise then that many foodstuffs contain potassium in high levels. However, naturally occurring potassium is ever so slightly radioactive. This is because it is comprised of three isotopes: ^{39}K, ^{40}K and ^{41}K. Both ^{39}K and ^{41}K are stable, however ^{40}K is not[2]. This is where the vast majority of the radioactivity in food arises from.

Bananas are renowned as a good source of potassium, amongst other things. Therefore, this paper will calculate just how radioactive a banana is, whether this is harmful, and how many bananas it would take to kill a person by radioactivity alone.

Discussion

Firstly, the amount of potassium in a banana needs to be known. Estimates vary [1,3], however a figure of 450mg will be used for this paper as this is approximately a mean value. Of this, only a small percentage of the total mass is represented by ^{40}K, around 0.0117% [3]. The half-life of this small fraction is around 1.26 billion years [4], making the decay very slow, and all this energy is delivered as gamma rays. In order to work out the damage done per banana, the amount of energy released per second shall be calculated. Using this formula,

$$E_T = \frac{N_A m E_D}{2t} \tag{1}$$

the energy released per second can be found. Here, E_T is the energy per second, N_A is Avogadro's number, m is the mass the sample, E_D is the energy of the decay (1.461 keV[5]) and t is the half life. Computing the mass of ^{40}K in a single banana gives a value of 52.65µg, and the number of seconds in a half life is 3.98×10^{16}. Formula 1 gives a value of 9.31×10^{-14} J/s. This is a very low amount of energy, however it is not immediately possible to see how much damage is done by this energy. For this, the number of Grays will be calculated.

A Gray is the amount of energy in joules absorbed per kilo of biological mass[6]. Assuming the body absorbs all radiation, a person weighs about 75kg and digestion takes around 24hrs, the dose of radiation will be

$$R_d = \frac{E_T t}{m_s} \tag{2}$$

where R_d is the radiation dose, t is the time and m_s is the mass of the stomach. This gives a value of $1.07x10^{-10}$Gy. This is a very small amount of radiation. It takes around 1Gy to cause radiation sickness in an adult [7], and it takes 4 times that to have a good chance of killing someone.

Calculating how many bananas someone would have to eat to have a good chance of killing them, therefore, is simple, as it is just a case of dividing the number of Grays (4Gy) to kill someone by the dose from a single banana. This gives approximately 37,290,000,000 bananas, far greater than the volume of a person. Taking this further, it would be interesting to see how many bananas would have to be in a room to kill a person. Assuming the radiation could penetrate other bananas, but would be completely absorbed by a person, it takes a month (28 days) to recover from the radiation and that the average person weighs 75kg, using formula 2 again yet changing the value of t gives a value of around 1,250,000,000 bananas. If the recovery time was longer, fewer bananas would be necessary. While this is significantly less than having to eat the bananas, it would still be an alarming amount. This represents around 0.0118% [8] of the global banana production per year, so while it is not theoretically impossible, it is practically so.

Conclusion

In conclusion, while a banana is radioactive, the levels of radioactivity are so low it would take a very large number of bananas to have any health affect. Even being surrounded entirely by bananas emitting gamma rays constantly, it would take a percent of the world's entire output to cause any negative effect.

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