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P3_1 What's Popping in the Nuclear Apocalypse?

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Abstract

We investigate the amount of popcorn that could be popped using the energy of all the nuclear weapons in the world. It is found that the energy required to pop on kernel of corn is $0.05099J$, and therefore that the energy released by such an explosion would be sufficient to pop 5.072×10^{19} kernels, or $6.898 \times 10^{16}kg$ of corn.

Introduction

On August 6, 1945, the USA dropped an atomic bomb on Hiroshima, Japan. The yield of this bomb was equivalent to 15 *kilotons* of TNT, and it killed over $130,000$ people. Since then, research into nuclear weapons has continued, with most global powers developing their own arsenal [1]. Developments have meant that nuclear weapons now have yields much higher than the 15 *kiloton* bomb dropped on Hiroshima, and many people have speculated on the consequences if these warheads were ever to be used. There are approximately $14,570$ nuclear warheads globally at the moment [2]. It's not difficult to see that if even a fraction of these were to detonate, the consequences could be dire on the popcorn industry.

Theory

Popcorn explodes when the water inside it is heated to it's vapour point, resulting in an expansion as it shifts into a gas phase. This causes a rapid rise in pressure within the kernel, and eventually the steam bursts through the shell, "popping" the kernel inside out. Due to the heightened pressure within the kernel, the vapour point of water is around 175°, while the percentage by mass of water per kernel is about 14% [3].

Because of this, it is relatively simple to calculate how much energy is needed to pop a single kernel of corn using its mass [4], as well as the specific and latent heats of water. This energy can then be compared to the hypothetical energy of every nuclear bomb detonating at once and, assuming that all of said energy is absorbed by popcorn kernels for heating purposes (and that they don't simply burn away), then the total number of kernels that could be popped can be found.

Results

One kernel of popcorn has a mass of $136 \times 10^{-6}kg$ and 14% of this mass is water. Since the a popcorn kernel pops due to the vaporisation of the water within the kernel, the total heat energy required to cook a single kernel is the sum of the heat energy due to the mass of the water within the kernel, Q_m, and the latent heat of vaporisation of the water, Q_v.

$$Q = Q_m + Q_v \tag{1}$$

Q_m is given by equation 2, where m is the mass of the water, c is the specific heat capacity of water, and ΔT is the change in temperature from room temperature, $21°C$, to the temperature at which water vaporises, $175°C$.

$$Q_m = mc\Delta T = (19.04 \times 10^{-6}) \times 4.186 \times 154 \quad (2)$$

Equation 2 gives Q_m as $0.01227J$. Q_v can be calculated as shown in equation 3.

$$Q_v = mL_v = (19.04 \times 10^{-6}) \times 2034 \quad (3)$$

Therefore, the total heat energy, Q, for one popcorn kernel is $0.05099J$.

U^{235} decays in the following way [2]:

$$U^{235} +^{1}_{0} n \rightarrow^{144}_{56} Ba +^{89}_{36} Kr + 3^{1}_{0}n \quad (4)$$

From the *A*4 5 *Nuclear Explosion* paper [2], the energy of all nuclear bombs is $2.586 \times 10^{19}J$.

Using the energy of all the nuclear bombs, and the energy required to pop one popcorn kernel, the total number of popcorn kernels that can be popped with all the nuclear bombs in the world is:

$$N = \frac{2.586 \times 10^{19}}{0.05099} = 5.072 \times 10^{20} kernels \quad (5)$$

This is equivalent to $6.898 \cdot 10^{16}kg$ of popcorn.

Discussion and Conclusion

In all, this is a monumental amount of popcorn. One serving of popcorn contains around 150 calories and weighs approximately $30g$ [5], so $6.898 \times 10^{16}kg$ of popcorn would contain 3.449×10^{20} calories, or 2.299×10^{18} servings. The daily recommended intake for men is 2,500 calories, or 2,000 calories for women, [6] so this amount of corn could feed one man for 1.380×10^{17} days (3.78×10^{14} years), or one woman for 4.725×10^{14} years. Alternatively, this would feed roughly 4×10^{14} people for one year.

Since there are 7.8 billion people alive on Earth at the time of writing (November 2020) [7], this would effectively feed the entire population for over $50,000$ years, providing relief from world hunger, which is a nice benefit considering the impending nuclear apocalypse.

References

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[3] `https://www.scientificamerican.com/article/explore-the-pop-in-popcorn/`[Accessed 22 November 2020]

[4] `https://agris.fao.org/agris-search/`[Accessed 22 November 2020]

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[7] `https://www.worldometers.info/world-population`[Accessed 23 November 2020]