# Vitamin C in Orange Chocolate vs Orange Fruit

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#### Abstract

This paper investigates the vitamin C in a Lindt chocolate orange bar compared with the vitamin C in an average California Valencia orange. A Lindt chocolate orange bar contains 2.38 g of orange, meaning that 76 bars would have to be eaten to consume the same amount of vitamin C as an average orange. The paper also looks at the effects of eating both 76 chocolate bars and 76 oranges. It was found that eating 76 chocolate bars would exceed the daily intake of sugar by 35 times and eating 76 oranges would increase the pH of the stomach from 2 to 1.7.

## Introduction

We often associate vitamin C with oranges due to their renowned high content. In a California Valencia variety of orange, there is 87.3 mg of vitamin C, with an average weight of 180 g [1]. The daily intake for an average male needed to maintain 'near-maximal neutrophil concentrations with minimal urinary loss' is 75 mg, found in a study conducted by Levine et al. [2, 3]. Therefore, eating one California Valencia orange will provide a person with 116.4 % of their daily recommended intake (equation 1). This will be different for woman, however the study only found values for males.

$$\frac{87.3}{75} \times 100 = 116.4\%.$$
 (1)

Vitamin C has many health benefits such as helping to form collagen as well as repairing and maintaining teeth and bones. It is an antioxidant which protects tissue from damage from free radicals that have the potential to cause cancer [4].

Chocolate is a popular food for many, with a survey showing that the average British person consumes 10kg per year [5]. Many chocolate brands include other flavours in their products including orange; which can be seen in Jaffa Cakes, Terry's Chocolate Orange, and Lindt Excellence Dark Chocolate Intense.

# Theory

A 100 g bar of Lindt Excellence Dark Chocolate Orange Intense contains 7 % orange preparation; within this, 34 % is orange [6]. Using this, the total orange content in a bar is equal to:

$$(0.07 \times 0.34) \times 100 = 2.38g. \tag{2}$$

An average California Valencia orange weighs 180g, therefore comparing the mass of orange in a chocolate bar to the mass of an average orange will give the number of chocolate bars needed to consume the same amount of the fruit (equation 3).

$$\frac{180}{2.38} = 76 \text{ bars. } (2 \text{ sf}) \tag{3}$$

As previously stated, the recommended daily intake of vitamin C is 75 mg. Therefore, the amount of chocolate bars to satisfy this intake is:

$$\frac{76}{87.3} \times 75 = 65 \ bars. (2sf) \tag{4}$$

Consuming this many chocolate bars, however, is not advised. One Lindt chocolate bar contains 41.7 g of sugar [6], so eating 76 is equivalent to consuming 3169.2 g of sugar. The maximum daily recommended intake of sugar is 90 g, so eating this many chocolate bars is over 35 times the limit [7].

Whereas eating 76 oranges would have different detrimental effects. Vitamin C is also known as ascorbic acid, with chemical formula  $C_6H_8O_6$ . In an average California Valencia orange, there is 87.3 mg

of vitamin C [1]. If 76 oranges were consumed, a person would ingest 6.63 g of vitamin C.

$$Moles (mol) = \frac{Mass(g)}{molar mass (gmol^{-1})}.$$
 (5)

The molar mass of ascorbic acid is 176.12 gmol<sup>-1</sup>, therefore using equation 5, there are 0.0376 moles. A fasted stomach contains 35 ml of liquid [8], so the concentration of ascorbic acid in the stomach can be worked out using the following equation:

$$Concentration = \frac{Moles}{Volume}.$$
(6)

The concentration of ascorbic acid equates to  $0.0376/0.035 = 1.074 \text{ mol dm}^{-3}$ . The  $pK_a$  of the acid is known to be 4.1 [9], therefore the  $K_a$  is  $10^{-4.1} = 7.943 \times 10^{-5}$ .

Ascorbic acid is a weak acid so doesn't fully dissociate. To find the concentration of  $H^+$  the following equations are used:

$$K_a = \frac{[H^+][A^-]}{[HA]} = \frac{[H^+]^2}{HA},\tag{7}$$

$$[H^+] = \sqrt{K_a \times [HA]} = \sqrt{7.943 \times 10^{-5} \times 1.074}$$
  
= 9.236 × 10<sup>-3</sup> mol dm<sup>-3</sup>

The pH of the stomach can greatly vary, with average pH of 2 [10]. This means the concentration of protons in the stomach is  $10^{-2} = 0.01$  mol dm<sup>-3</sup>. This value can be added to the concentration of protons in ascorbic acid, as they are both within the same volume, to give total proton concentration of:  $0.01 + 9.236 \times 10^{-3} = 0.0192$  mol dm<sup>-3</sup>. This would give a final pH of -log 0.0192 = 1.7 pH. This change in pH would disrupt metabolic processes and enzymatic activity in the stomach.

### Conclusion

Chocolate is a popular food in Britain, leading to the development of different flavours such as orange chocolate. Comparing the orange content in a Lindt orange bar, it is calculated that 76 bars would have to be eaten to consume the same amount of vitamin C as an average California Valencia orange. Eating this many chocolate bars would mean a person consumes 35 times more sugar than the daily recommended intake. Whereas eating 76 oranges would increase the pH of the stomach from 2 to 1.7.

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