

## How much comfort can you get from a chocolate bar?

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### Abstract

The purpose of this paper was to explore a hypothetical experiment to identify a correlation between the change in blood serotonin levels and mood in an individual after a fixed quantity of chocolate is ingested. Blood levels would be taken 0, 1 and 2 hours and expressed as nano-grams per millilitres (*ng/ml*) of serotonin. Mood changes would be assessed using the Bond-Lader Visual Analogue Scales.

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### Background

There is a longstanding association between food and mood. It is well established that many individuals' moods are uplifted after ingesting chocolate [1]. Popular claims indicate that the properties of chocolate enable it to be a stimulant, relaxant, euphoriant, aphrodisiac, mood enhancer and an antidepressant [2, 3].

There are over 300 naturally-occurring chemicals in chocolate with differing properties. Flavanoids are also present in chocolate. There has recently been increasing interest in the field of cardiovascular medicine in their potential benefits of improving blood flow and decreasing cholesterol [4]. Cocoa, the key ingredient in chocolate, contains caffeine and theobromine. Studies suggest that theobromine, which is a methyl-xanthine, stimulates mood and is an active antioxidant in average doses but may have a negative impact in higher concentrations [5].

The majority of the positive effects on health of chocolate are as consequence of the release of neurotransmitters. One chemical in particular, tryptophan, promotes the release of serotonin (an anti-depressant in the brain) which results in an elevated mood. It functions in promoting the body's peristalsis and increases vasoconstriction. Both serotonin and its precursor tryptophan are present in chocolate [6].

The effect of chocolate on mood can be assessed in many ways but this paper will focus on the hypothetical correlation between the amount of

chocolate ingested and variability in cocoa percentage with changes in serotonin levels in the individual and its effect on mood.

### Methodology

For the purpose of this hypothetical experiment five varying cocoa percentages of Lindt chocolate and four varying percentages of Green and Blacks chocolate were chosen (table 1). One chocolate bar would be consumed each day in a randomised order. Normal blood levels of serotonin range from 101 to 283 *ng/ml* [7]. Chocolate made with 85 % cocoa is said to contain serotonin 2.9  $\mu\text{g/g}$  [8]. The aim would be to determine a relationship between serotonin levels and mood following the consumption of chocolate. The effect on serotonin release post ingestion is short lived. Therefore, the time points for blood sampling and mood assessment would be at 0, 1 hour and 2 hours.

The amount of serotonin ingested needs to be taken into account in order to have an accurate baseline. The level measured reflects the effect of mood enhancement and serotonin release from the brain as well as that produced in the intestine [9].

Equation 2 was deduced using equation 1 in order to calculate how much serotonin is expected to be present for different percentages of chocolate ingested. 85 % cocoa and 2.9  $\mu\text{g/g}$  serotonin was used to obtain the constant 0.034.

$$\text{Constant} = \frac{\text{Serotonin } (\mu\text{g/g})}{\text{Cocoa } \%} \quad (1)$$

$$\text{Serotonin Content } \left(\frac{\mu\text{g}}{\text{g}}\right) = 0.034 \text{ Cocoa } \% \quad (2)$$

Mood changes would be assessed by a validated Visual Analogue Scale (VAS) as per Bond Lader. The individual uses 10 cm linear scale and places a mark between two statements indicating how they feel at that moment. VAS seems to be more sensitive to smaller changes in subjective states and is not affected by the ‘wording’ of the responses in alternative mood scales so it is more suited to this study unlike the case in Likert Scales [10].

### Results

Type	Cocoa (%)	Serotonin content (µg/g)
Lindt	99	3.38
	90	3.07
	85	2.9
	70	2.39
	30	1.02
Green and Blacks	85	2.9
	70	2.39
	37	1.26
	30	1.02

Table 1) shows the serotonin content of different percentages of Lindt and Green and Blacks chocolate.

### Assumptions

It would be assumed that the individual has a normal lifestyle, would be on no medication, has a daily routine and their diet does not vary throughout the study period. Dietary exclusions must include other chocolate, caffeine and other foods containing high tryptophan levels. The study would exclude factors that would influence baseline serotonin levels or affected the change in serotonin levels following chocolate ingestion. For the purposes of the study the transit time of the individual’s intestine must also be assumed to be within normal limits. Furthermore, this paper focusses on the short term mood enhancing effect of chocolate and any complex interplay of carbohydrate and protein metabolism is not taken into account.

### Discussion

This proposed methodology for an experiment is based on a hypothetical model as such there are two possible hypotheses for the results.

The most likely outcome would be that the maximum level of serotonin measured correlates with the greatest percentage of cocoa ingested. The maximum peak of serotonin level is also expected to have a strong correlation with the improvement in mood scale approaching a coefficient of 0.8 or 0.9.

However the correlating mood is open to interpretation because it is not known whether the individual has pre-existing like for dark versus milk chocolate or vice versa. If so, this would have an effect on the consequent mood scale for the individual.

The Bond -Lader VAS would be more suited to assess mood for this study as changes would need to be detected within a short time interval of 1-2 hours.

The alternative outcome is a negative result where there is no association between mood changes following chocolate ingestion and measurements of serotonin. Several contributory factors could account for this including, the many other chemicals present in chocolate and the release of other endorphins and neurotransmitters that may affect mood.

Another factor to consider is satiety. This proposed experiment uses a standard 15 g chocolate bar. For those who have a predilection for chocolate this may not achieve peak mood as it is an insufficient quantity.

This study has not taken into account the well-known association that eating chocolate has an immediate effect on the mood in some individuals. This could be assessed by using the Bond-Lader scale every 10 minutes in the immediate post ingestion period. However, tryptophan and serotonin metabolism is not immediate and hence unlikely to be a contributory factor for this effect.

### Conclusion

This paper investigated an avenue for obtaining a scientific, objective measurement of how much comfort one can obtain from eating a chocolate bar. However, in reality this is significantly based on emotional responses which has a high individual variability.

## References

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