Using Smartphones to Hack Human Micronutrition

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Abstract

Micronutrient deficiencies are a global issue, and their detection is invasive and expensive. As a step towards mitigating this barrier, we explore the application of spectrophotometry to determine vitamin concentrations in a solution using only a smartphone.

Research Question

Can a smartphone-based spectrophotometer quantify micronutrients in a solution?

Background

- Micronutrient imbalances are preventable and have major downstream health effects
- Status assessment of micronutrients is often done via complex analyses on blood (e.g. LC-MS).
- Algorithms have been developed to quantify micronutrients present in complex mixtures based on spectrophotometry (MILCA).
- Separately, efforts have been made to develop methods of mobile spectrophotometry.

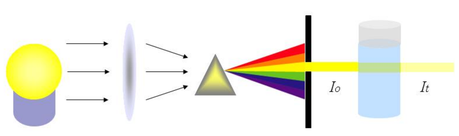

Fig 1. Principles of spectrophotometry, Source: Spectrophotometry – Chemistry Libretexts

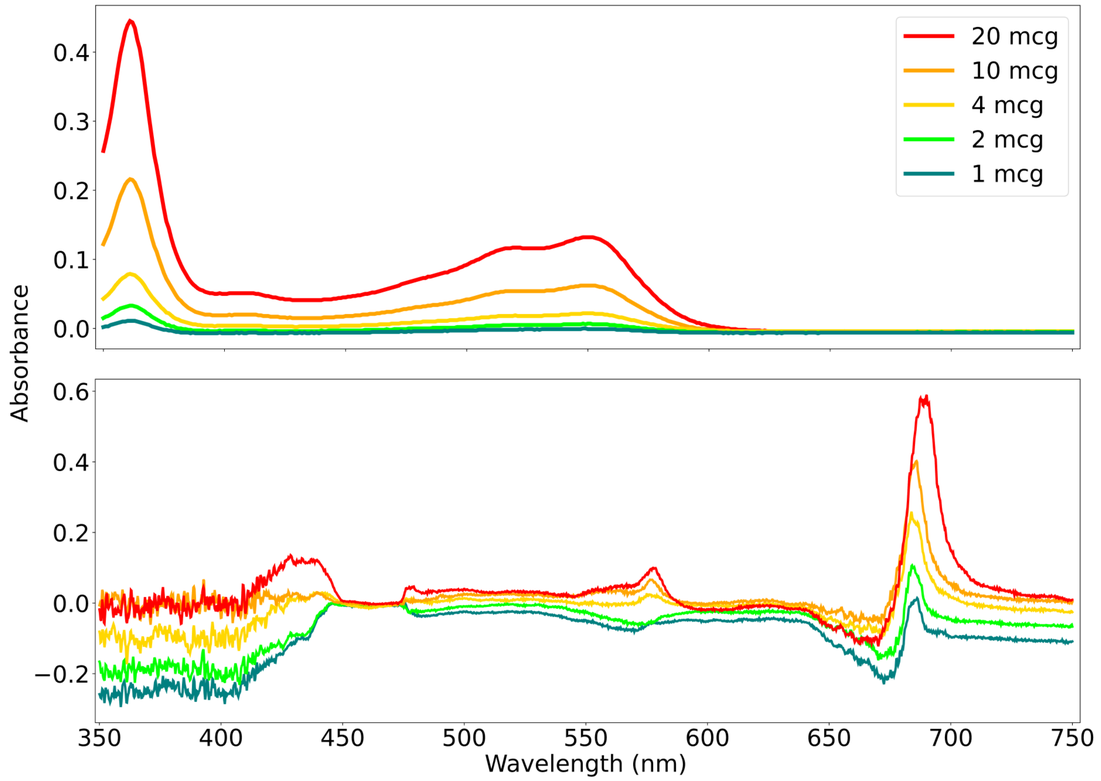

Fig 2. Lack of agreement between absorbance peaks at 361 & 551 nm for lab device (top) and 577 & 690 nm for smartphone device (bottom)

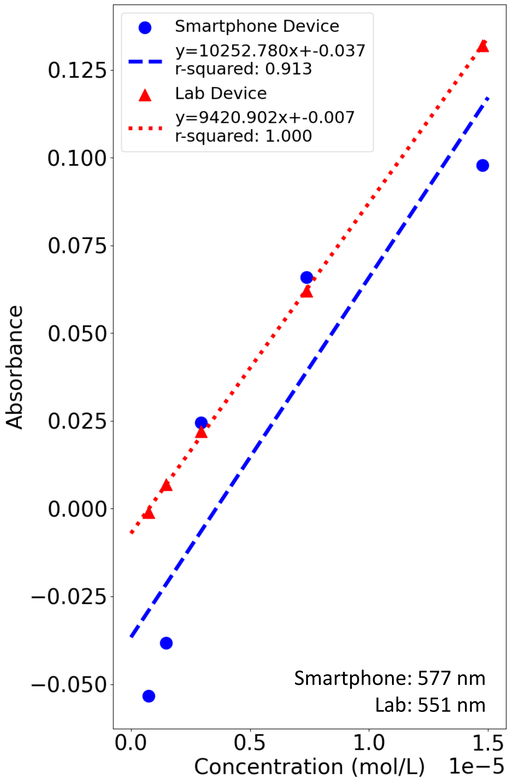

Fig 3. Absorbance and concentration relationship is weaker for smartphone device

Approach

1. Tested a variety of micronutrients with a prototype spectrophotometer, selected B12 as a case study.
2. Built upon an existing smartphone-based design.
3. Developed a processing pipeline to convert smartphone images to spectra.
4. Experimented with different light sources, processing parameters, and sample concentrations in water.
5. Compared results to a lab spectrophotometer.

Take Aways

- Light source was a critical parameter.
- Explored methods of smartphone-based analysis are unreliable, do not align with lab device.
- On the lab device, both methyl- and cyano-B12 follow Beer's law at 3 distinct peaks, reach a limit of detection at 1 mcg/mL.
- Future work should focus on a mobile device that can reproduce lab results and experiment with MILCA and machine learning algorithms for complex samples.