V CONGRESO INTERNACIONAL DE DIDÁCTICA DA QUÍMICA

Mobile-Enabled measurement of controlled release in High School: Enhancing Learning and Laboratory Capabilities

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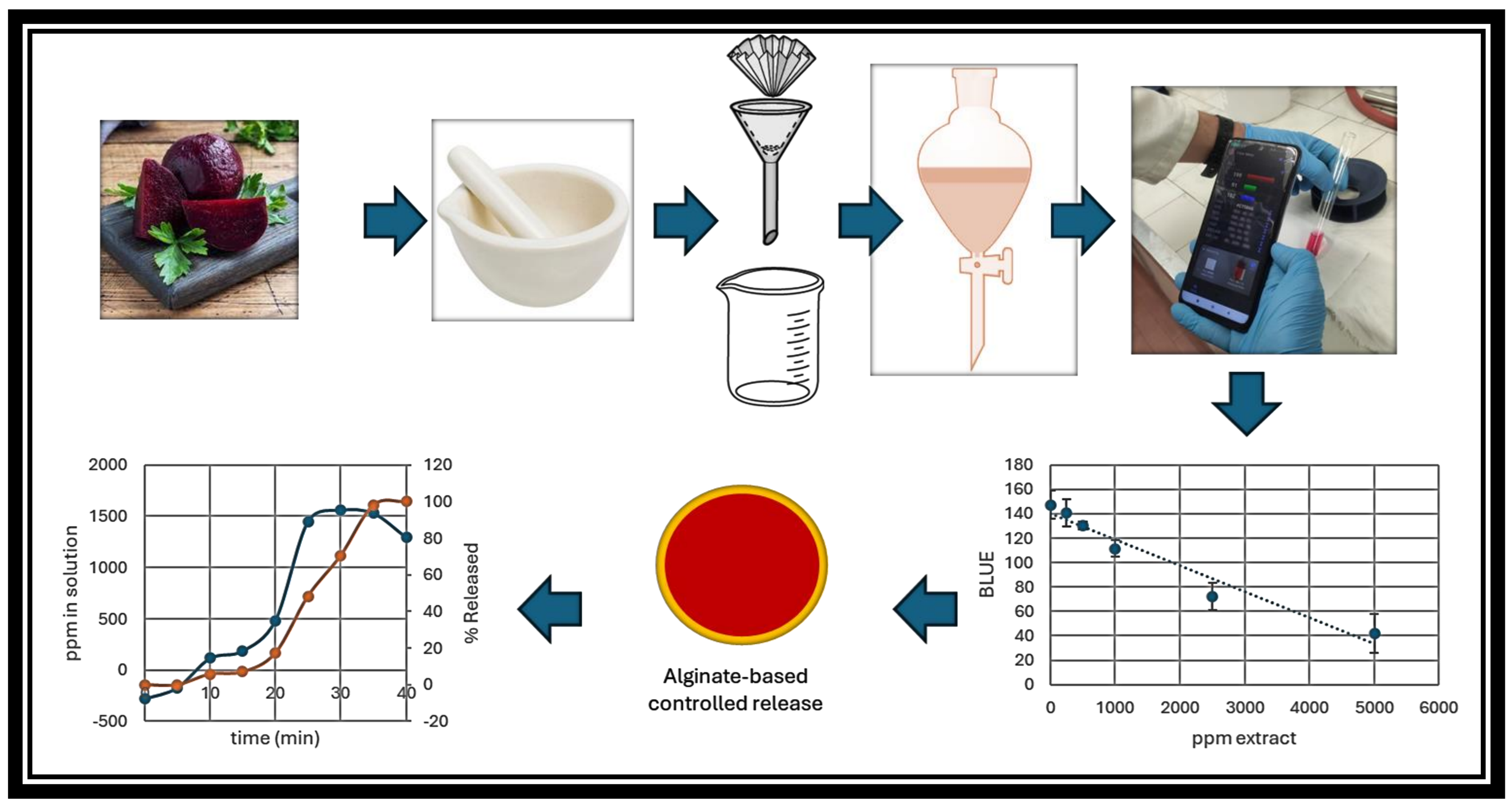


ABSTRACT

Utilizing mobile phones during leisure time has become commonplace among students. However, they can also serve as valuable tools to introduce advanced concepts and enhance the capabilities of high schools facing resource limitations. In a recent activity, high school students employed their mobile phones along with two free applications to explore the quantification and calibration of a natural extract of betalains derived from beetroots.

This extract was prepared through a series of steps involving cutting, grinding, and separation from the lipidic fraction using petroleum ether. Students experimented with standard solutions and various dilutions, generating a calibration curve with a high correlation coefficient ($R^2 \approx 0.95$) and determining the concentration of the extract. Furthermore, they demonstrated the concept of controlled release of drugs or nutraceuticals using the spherification technique with calcium alginate, yielding impressive outcomes.

This initiative paves the way for broadening the capacities of educational institutions in their laboratories and exploring the potential application of colorimetry in analyzing complex food matrices.

Activity details

The experimental session is planned inside the MUR (Ministero dell'Università e della Ricerca) project "Piano Lauree Scientifiche," whose objective is to bring university knowledge closer to High Schools. The laboratory class consists of extracting the pigment known as betacyanin from the betalain family. Betalains, sourced primarily from plants within the *Caryophyllales* order. These pigments are classified into two main types: betacyanin, which imparts a violet color, and betaxanthins, which contribute a yellow hue. Apart from their role in plant coloration, betalains exhibit notable biological effects.

To extract the betalains, they ground a beetroot (Beta vulgaris) with mortar and water, filtered it, and separated the organic part with a bit of petroleum ether in a solvent extractor hood. In this way, students distinguished between two immiscible liquid phases, and eliminated the extract's fatty phase and lipidic components.

Once they had recovered the extract, they proceeded to experiment two, whereby using serial dilutions of the extract and a calibration curve (built by them thanks to a lyophilized extract provided by the instructor), a quantity of grams of extract per purified mL is given, learning also basic knowledge of dissolutions and dilutions.
The quantification was performed using Color Meter - RGB HSL CMYK RYB application (version 1.5.1),

Experiment three continues by specifying the extract by dissolving it in the sodium alginate and pipetting it drop by drop with a 2.5mL plastic Pasteur in a CaCl2 solution. Subsequently, students collected aliquots every 5 min for 40 min to study a release curve of betalains from the polymer matrix. This last experiment explains the importance of controlled release in the nutraceutical field and food additives, teaching them also the basic concepts of spherification that they commonly see in products and cooking.

Theorical explanation (powerpoint) ~ 0.75h

Experiment one: Beetroot extraction
1. Cut beetroot.
2. Grind in the presence of water.
3. Filtering.
4. Separation with petroleum ether.
5. Sample recovering.
~ 1.5h

Chemistry concepts: Extraction techniques, miscibility and filtration.

Student learning concepts: Experimental technique, safety, application of theory, teamwork.

Experiment two: Extract quantification
1. Preparation of standards.
2. Dilution of the extract.
3. RGB measurement.
4. Calibration and analysis.
~ 1 h

Chemistry concepts: Dissolution, dilutions, units, calibration curve, quantification.

Student learning concepts: Experimental Design, mathematical skills, graphical analysis, experimental error.

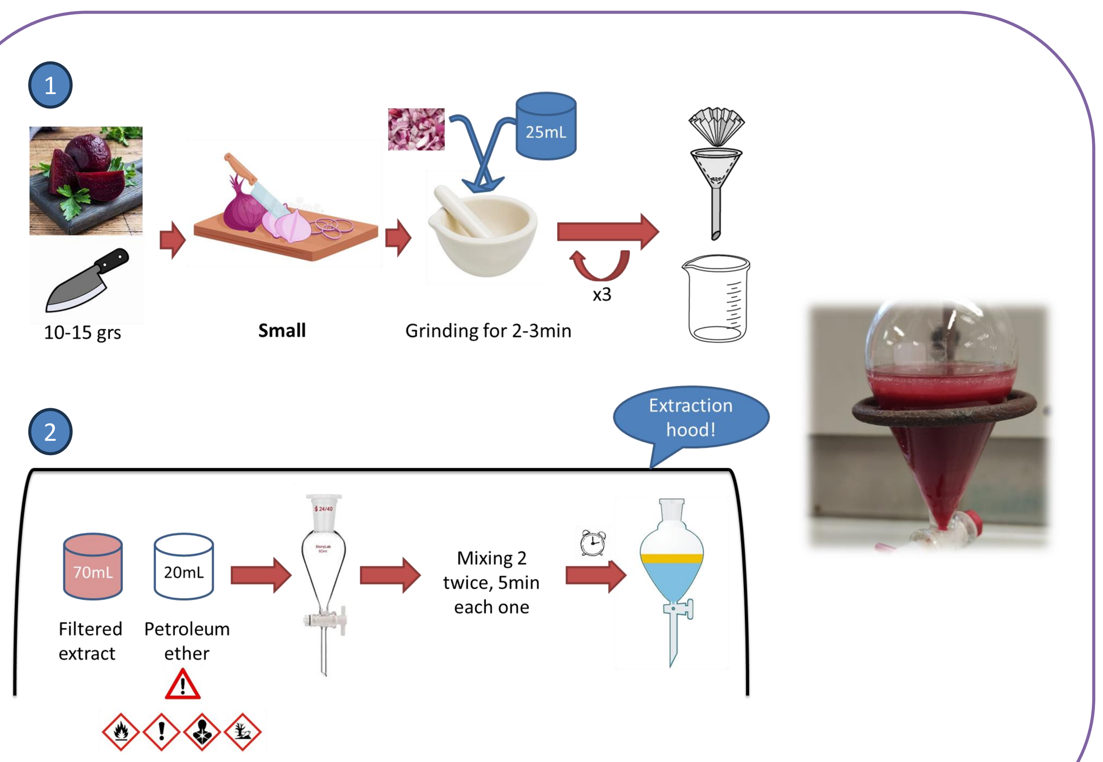
Experiment three: Spherification and release
1. Preparation of spheres.
2. Sample obtaining.
3. RGB measurement.
3. Analysis.
~ 1 h

Chemistry concepts: Spherification, polymer chemistry, ion exchange, release kinetics, time-dependent processes.

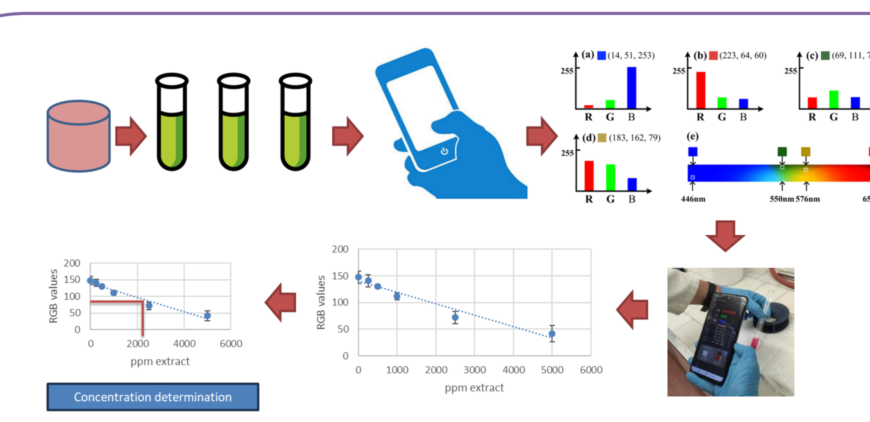
Student learning concepts: Experimental Design, graphical analysis, interpretation of results.

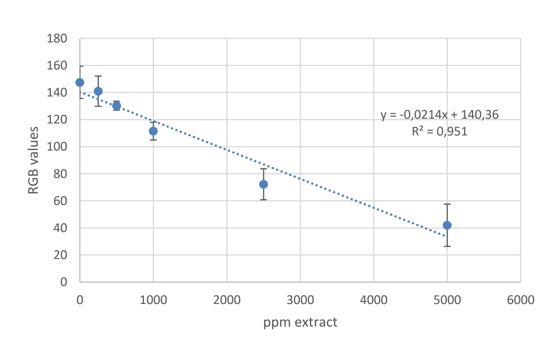
RESULTS AND DISCUSSION

1 Extraction



2 Quantification

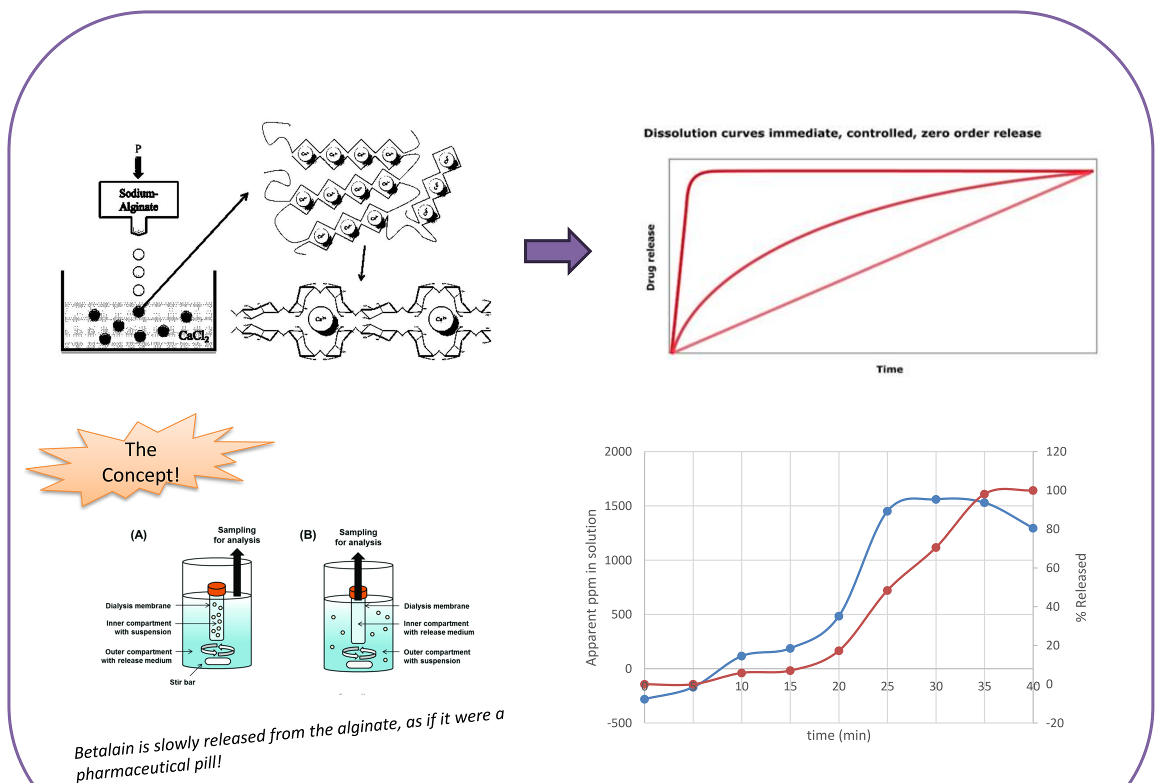




Quantification of extracts according to BLUE values and average linear regression						
Sample	BLUE_A	ppm	BLUE_B	ppm	BLUE_C	ppm
d1/2	55	3994	30	5164	27	5304
d1/4	81	2777	70	3292	70	3291
d1/8	115	1186	103	1748	105	1654

Good linearity, reproducible, and easy!

3 Controlled release



CONCLUSION

This initiative paves the way for broadening educational institutions' laboratory capacities and exploring the potential application of colorimetry in analyzing complex food matrices.

Bibliography

Matencio, A., Brunella, V., Trotta, F., Implementation of Smartphone-Assisted Colorimetric Assay for Metabolite Measurement in Plant Extract Using Primary Colors. Journal of Chemical Education (2024, Under review).