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Polysaccharide-derived hydrogel matrix-based platform for beverage quality monitoring

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INTRODUCTION & AIM

- Contaminant monitoring in beverages is critical for consumer health and product integrity.
- Conventional detection methods are often labour-intensive, costly, and not portable.
- Need for eco-friendly, low-cost, on-site sensing platforms that can provide rapid and reliable signals.

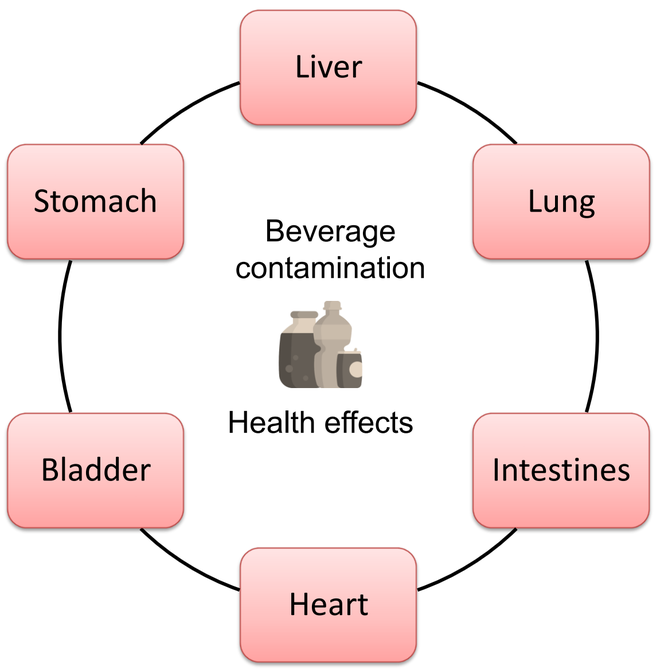
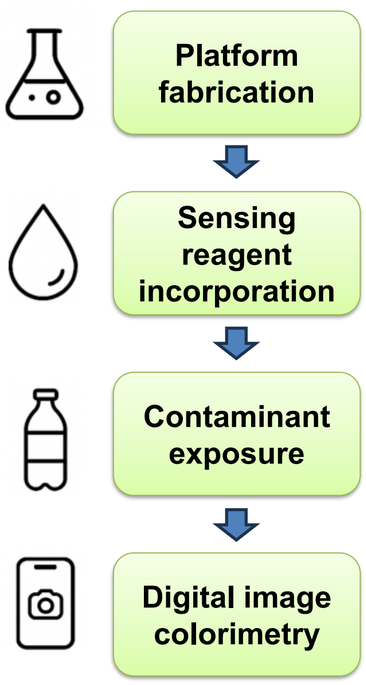


Fig: Ill effects of consumption of contaminated beverages on various body parts

Aim : To develop a polysaccharide-derived hydrogel matrix (PGM) capable of colorimetric monitoring of beverage quality.

METHOD



PGM preparation under eco-friendly conditions
- Optimized process parameters
- Robust cellulosic support

Incorporation of specific indicator in PGM
- Ensures consistent color response
- Casting of PGM in structured form

PGM exposed to BPA contaminated beverage samples
- Contact established under controlled conditions for calibration

Digital image captured using smartphone
- Image acquisition
- Image processing for RGB analysis

Quantitative analysis of image-based data
- Reproducibility examination across replicates
- Real beverage sample testing

Fig: Stepwise methodology for development and testing of sensing platform

PGM Properties and Performance Studies

- Optimization of process conditions for PGM platform preparation to obtain
  - Stable, porous structure supporting fast analyte diffusion.
  - Good water retention, facilitating rapid color response.
  - Enhanced handling with cellulose support layer.
- Indicator distribution within the PGM for uniformity, ensuring reproducibility and reliable performance.

RESULTS & DISCUSSION

Colorimetric Response

- Exposure to target contaminants produced distinct, visible color changes (c1-c5: 2-50 µM).
- Color intensity trends were qualitatively consistent across replicates, supporting reliability.
- Smartphone-derived greyscale intensity followed a monotonic trend with analyte presence.
- PGM platform tested with bottled beverages and drinking water.

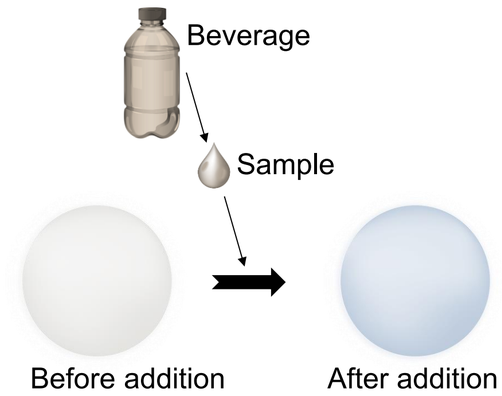


Fig: Colorimetric transformation on addition of contaminated sample

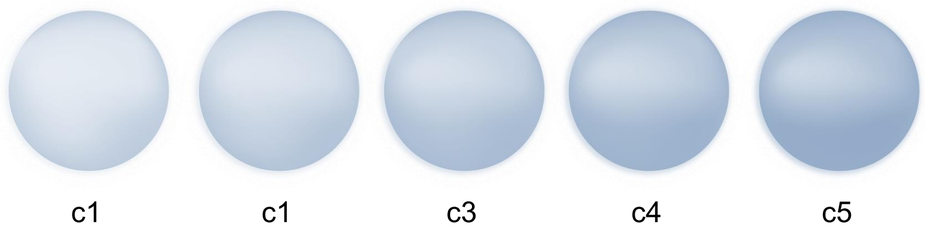


Fig: Variation in color intensity with concentration for different samples

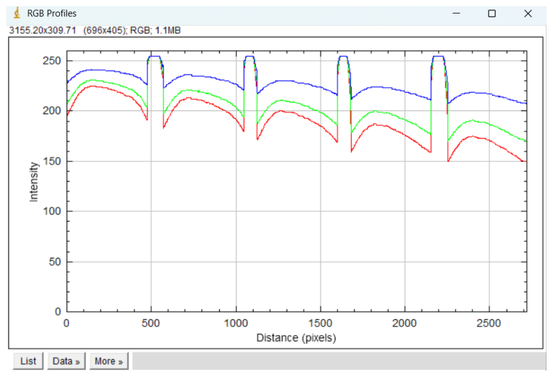


Fig: Digital image colorimetry to obtain RGB profiles for various samples

Table: Average RGB values for samples

Sample	R	G	B
c1	218	225	238
c2	205	215	232
c3	195	206	228
c4	176	192	220
c5	165	183	214

Practical Implications

- Rapid, low-cost, and user-friendly sensing approach suitable for non-laboratory environments.
- Renewable polysaccharide hydrogel matrix contributes to sustainability and eco-friendly packaging.
- Integration with smartphone-based digital imaging enables quantitative monitoring.

CONCLUSION

- Developed a polysaccharide-derived hydrogel matrix for colorimetric beverage quality monitoring.
- Smartphone-assisted digital imaging provided a simple, accessible method for on-site quantification.
- Platform demonstrated practical applicability with real beverages while remaining eco-friendly and cost-effective.

FUTURE WORK / REFERENCES

- Expand testing to a wider range of beverage contaminants.
- Integrate smartphone apps for image processing and quantitative reporting.
- Conduct long-term stability, regulatory compliance, and sustainability assessments for real-world deployment.

References -

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- Lin, X., Yan, H.,Zhao, L., Duan, N., Wang, Z., & Wu, S. (2024). Hydrogel-integrated sensors for food safety and quality monitoring: Fabrication strategies and emerging applications. Critical Reviews in Food Science and Nutrition, 64(18), 6395-6414.