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# Design and Simulation of a Smart Arrow Photonic Crystal Fiber Sensor for Multimodal Optical Detection of Food Adulteration

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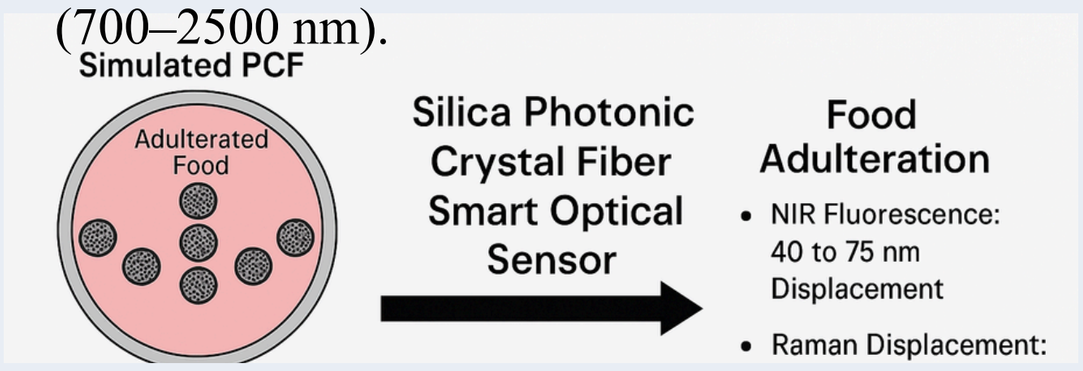
## INTRODUCTION & AIM

- Food adulteration threatens global health, while traditional detection methods are slow and destructive. Optical spectroscopy offers fast, non-destructive analysis but still needs a compact and highly sensitive sensing platform.

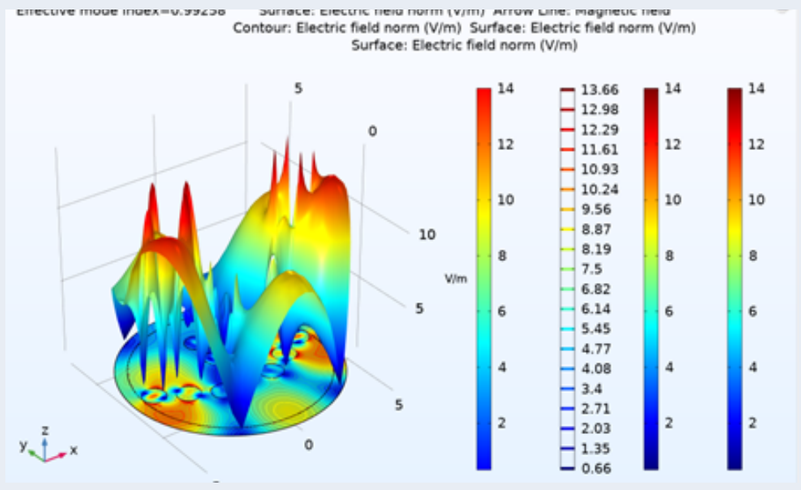
- This work designs and simulates a high-sensitivity ARROW Photonic Crystal Fiber sensor in COMSOL to detect food adulterants using NIR light (700–2500 nm).

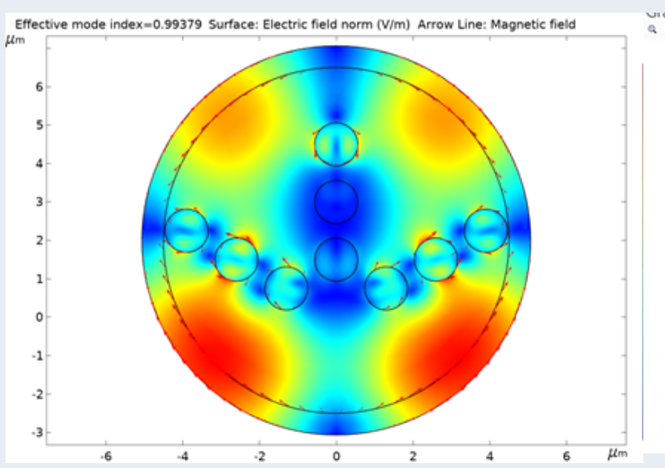


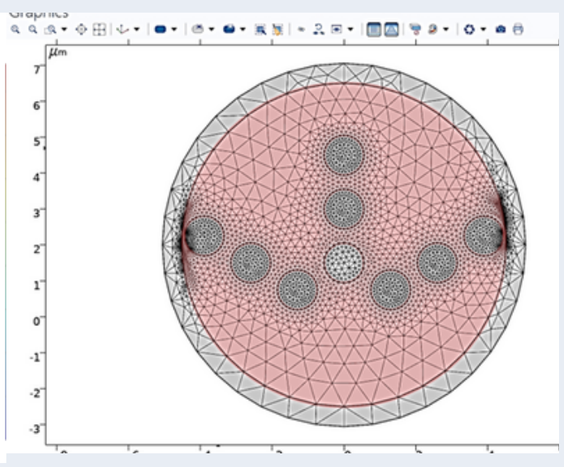

## METHOD

- ARROW PCF modeled in COMSOL shows strong evanescent interaction with analytes using, field distribution, and confinement loss analysis.

- Detection uses absorbance, fluorescence, Raman shifts with high sensitivity and clear spectral changes in adulterated samples.



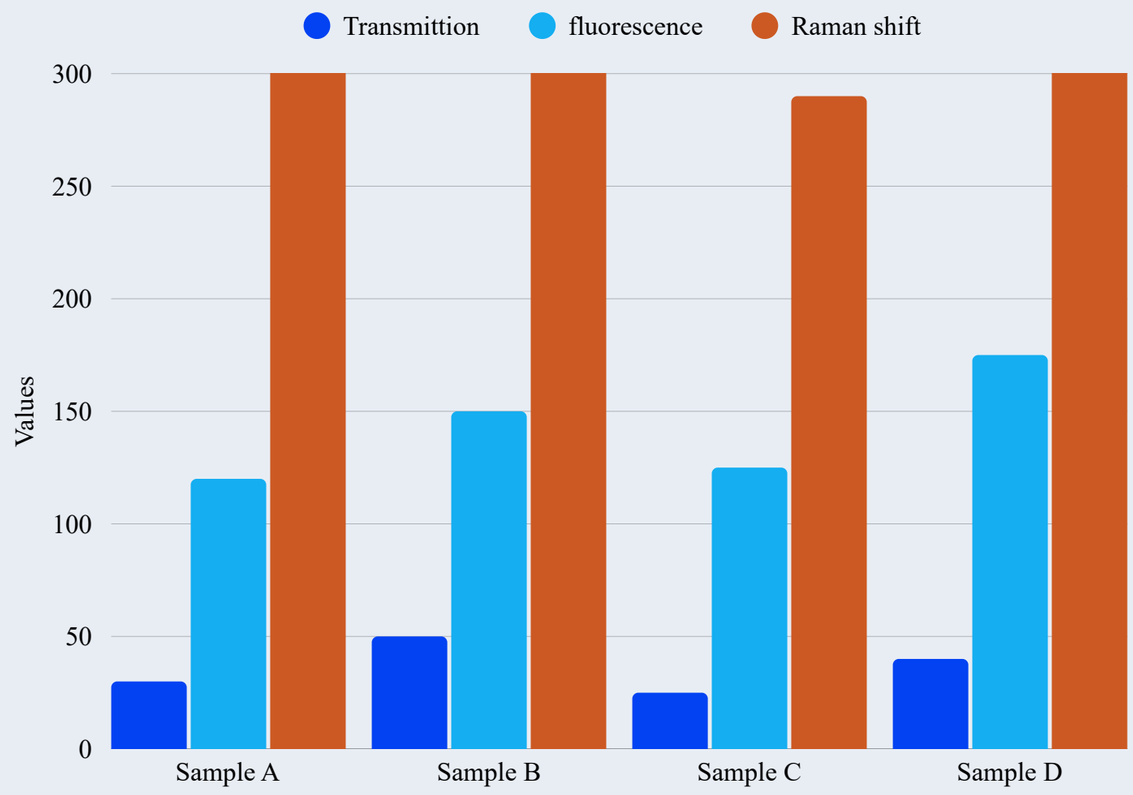



## RESULTS & DISCUSSION

- n_eff decreases with wavelength; adulterated samples show stronger absorbance, weaker transmittance, and clear spectral shifts.

- Wavelength rise lowers neff, and adulteration causes sharper absorbance, transmittance loss, and spectral shifts.




## CONCLUSION

| Sample Type | Absorbance (a.u.) | Transmittance (%) | Fluorescence Shift (nm) | Raman Shift ($cm^{-1}$) | Sensitivity (%) |
|---|---|---|---|---|---|
| **Pure Sample 1** | 0.85 | 70 | 40 | 200 | 98.4 |
| **Pure Sample 2** | 0.87 | 68 | 42 | 220 | 98.4 |
| **Adulterated Sample 1** | 1.05 | 50 | 65 | 600 | 98.4 |
| **Adulterated Sample 2** | 1.1 | 45 | 72 | 720 | 98.4 |
| **Adulterated Sample 3** | 1.2 | 40 | 75 | 800 | 98.4 |

Arrow PCF offers fast, non-destructive, 98.4%-accurate NIR adulterant detection for real-time food safety

## FUTURE WORK / REFERENCES

The sensor can be optimized for wider adulterant detection, integrated into portable devices, and enhanced with machine-learning–based spectral analysis for real-time, on-site food quality monitoring.