

Polycaprolactone nanoparticles for encapsulation black pepper extract

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AI disclosure: AI tools were used for text editing and layout support. All scientific content and conclusions are the authors' responsibility.

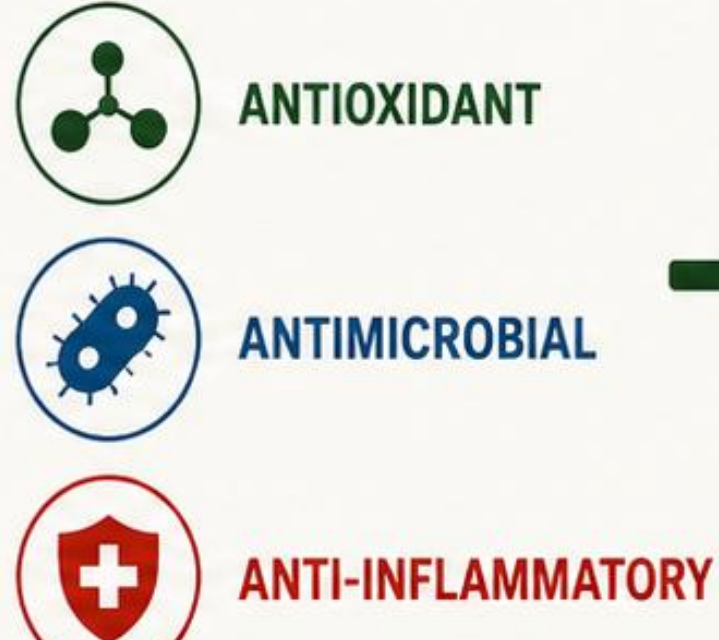
INTRODUCTION

BLACK PEPPER

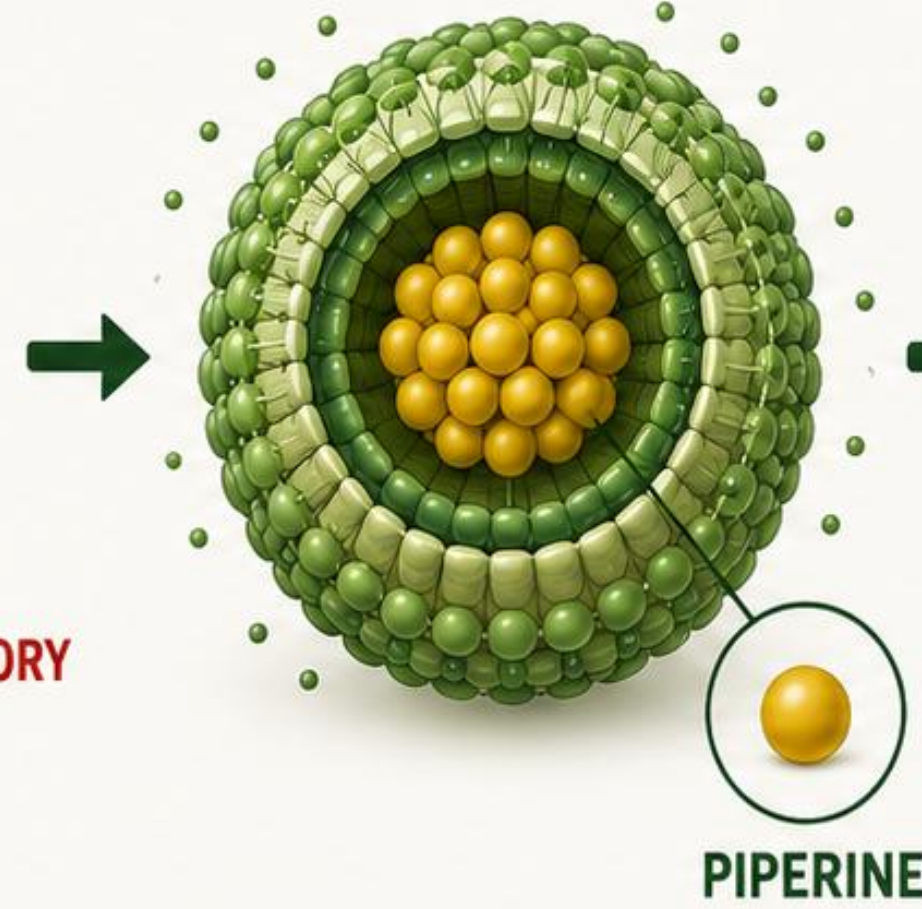


Black pepper, a fruit widely used as a condiment and in traditional medicine, exhibits antioxidant, antimicrobial and anti-inflammatory activities.

BIOLOGICAL ACTIVITIES



NANOCARRIERS IMPROVE STABILITY, BIOAVAILABILITY AND ALLOW CONTROLLED RELEASE



PIPERINE NANOFORMULATIONS ENHANCE EFFICACY AND SAFETY

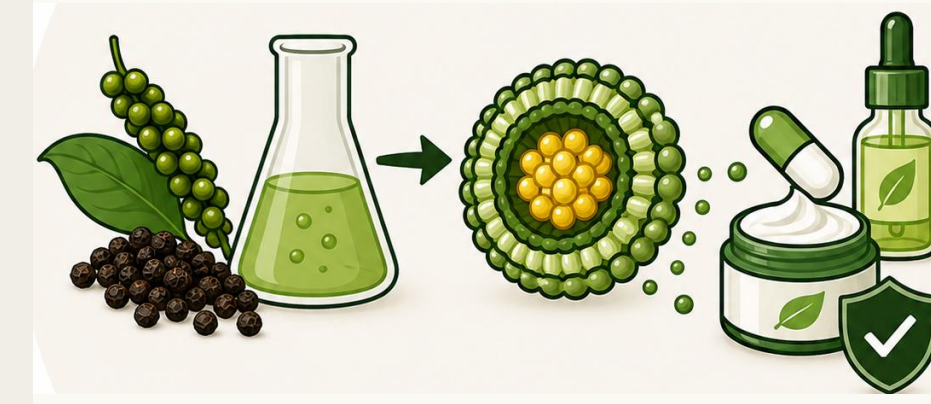
PHARMACEUTICAL APPLICATIONS



COSMETIC APPLICATIONS



OBJECTIVES

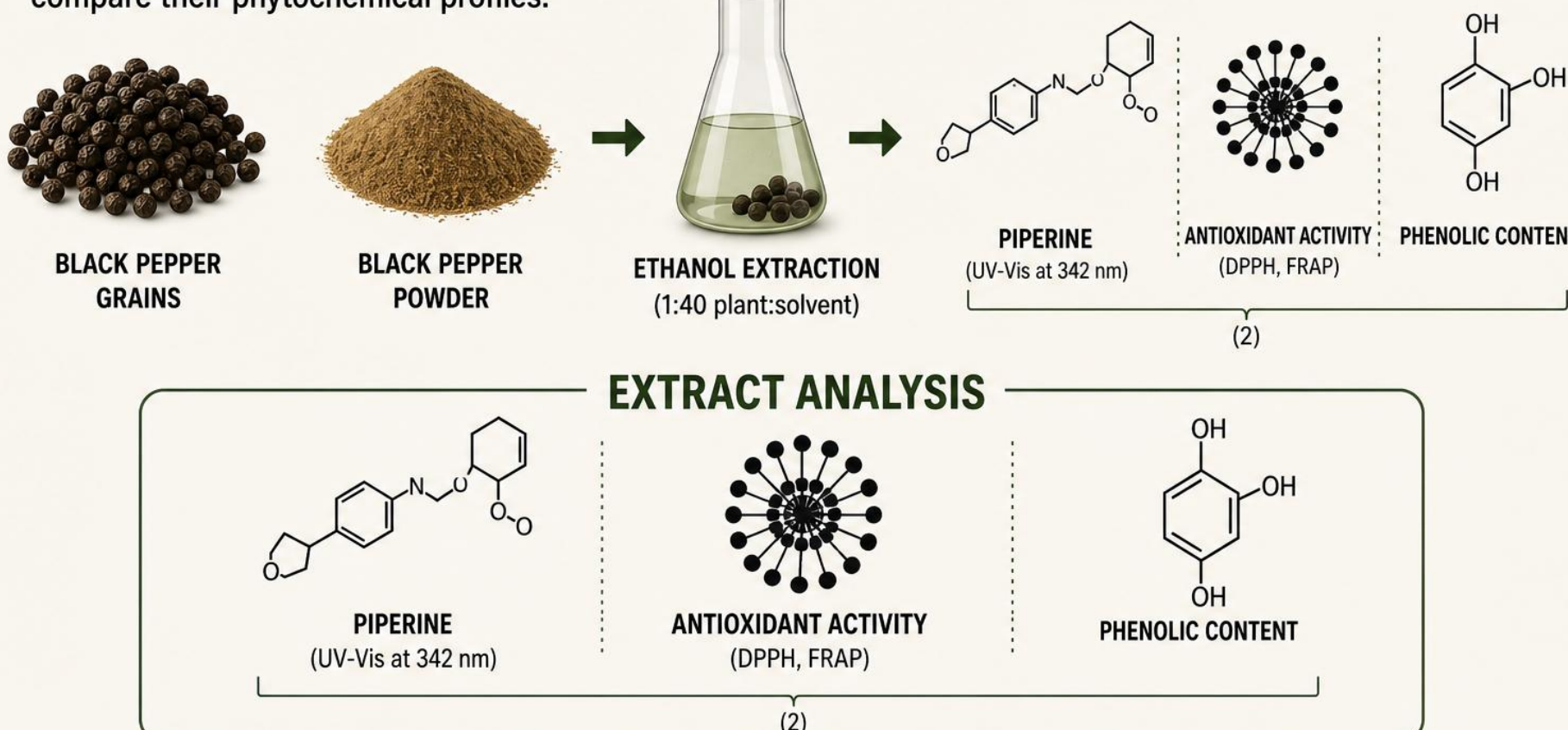


To **extract** and **evaluate** black pepper's constituents, followed by **encapsulation** to assess piperine's **release profile** and **nanoformulation stability** for **pharmaceutical** and **cosmetic applications**.

METHODS

1 EXTRACTION AND PHYTOCHEMICAL ANALYSIS

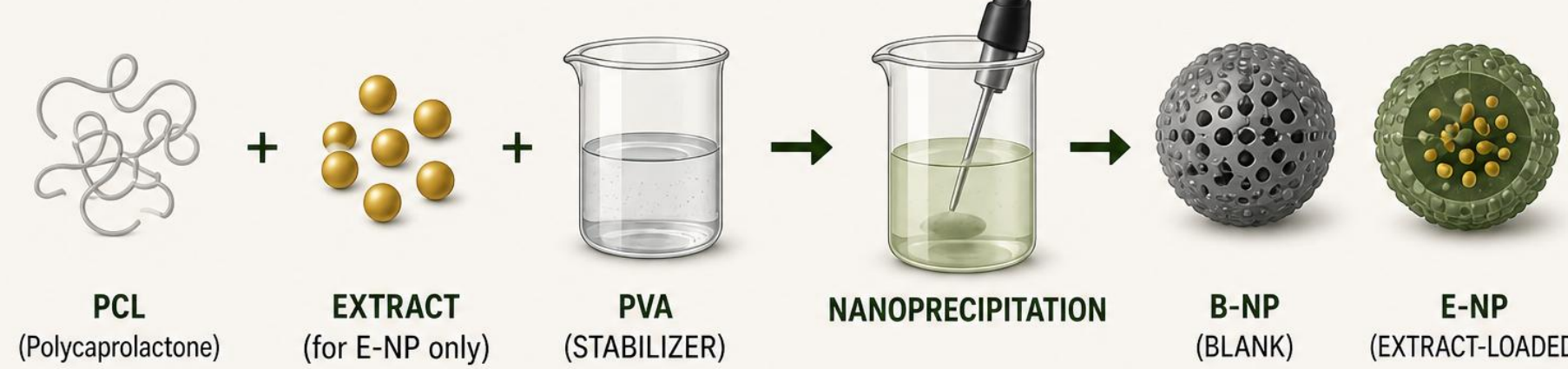
Black pepper grains and powder were separately extracted with ethanol (1:40 plant:solvent) to compare their phytochemical profiles.



(2) Reference: Pharmacological and cosmetic properties of piperine.

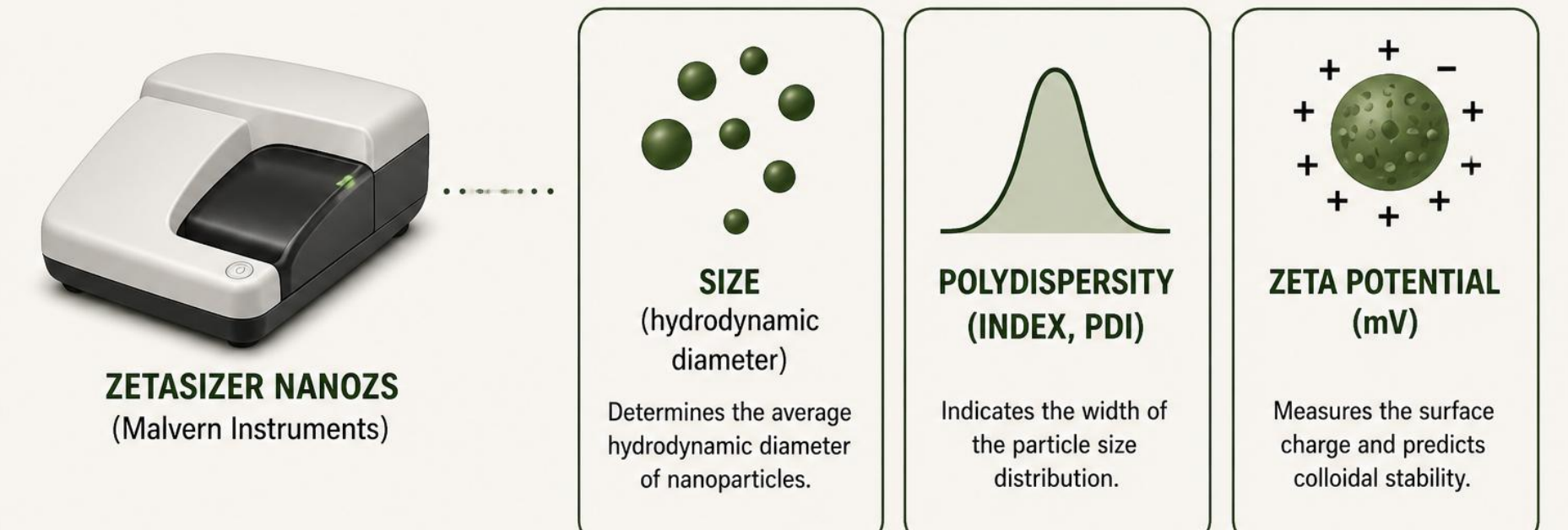
2 NANOPARTICLE PREPARATION

Polycaprolactone (PCL) nanoparticles, blank (B-NP) and extract-loaded (E-NP), were produced by nanoprecipitation using PVA as a stabilizer.



3 NANOPARTICLE CHARACTERIZATION

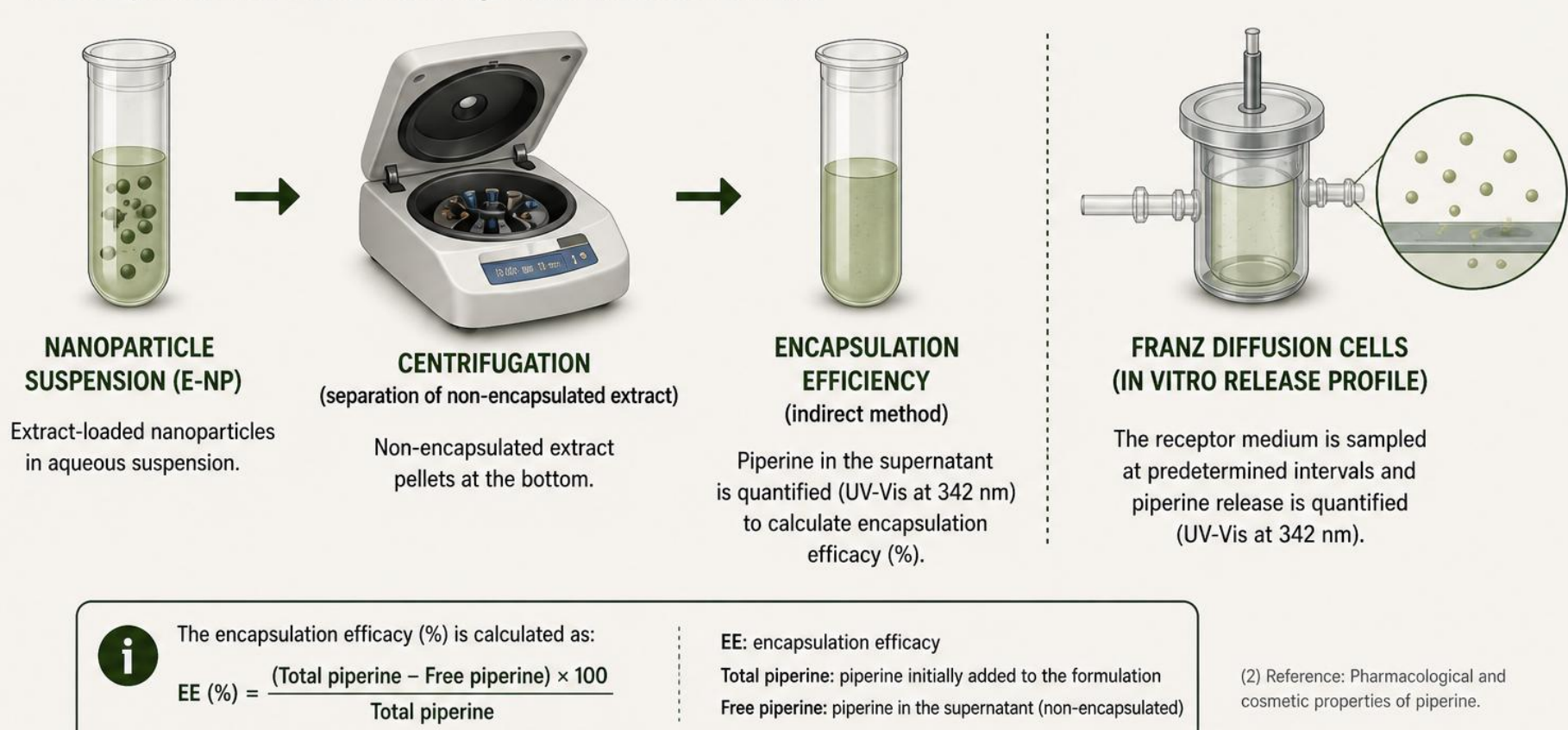
Nanoparticles were characterized for size, polydispersity, and zeta potential using Zetasizer NanoZS.



Measurements were performed using dynamic light scattering (DLS) for size and PDI, and electrophoretic light scattering (ELS) for zeta potential.

4 ENCAPSULATION EFFICACY AND IN VITRO RELEASE

Piperine encapsulation efficacy was determined by an indirect method using centrifugation to separate non-encapsulated extract, and the in vitro release profile was assessed using Franz diffusion cells (2).



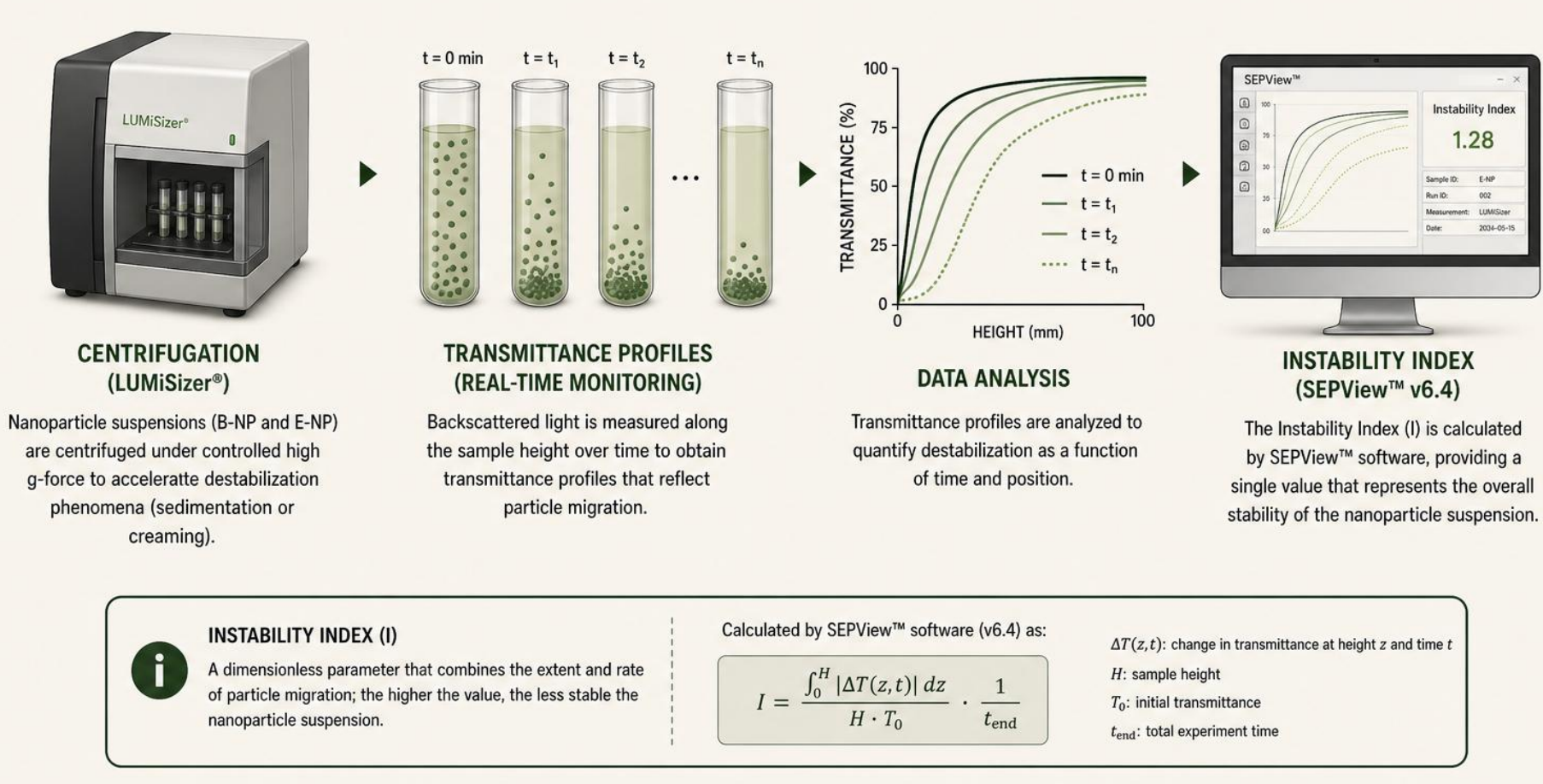
The encapsulation efficacy (%) is calculated as:
 $EE (\%) = \frac{(\text{Total piperine} - \text{Free piperine}) \times 100}{\text{Total piperine}}$

EE: encapsulation efficacy
Total piperine: piperine initially added to the formulation
Free piperine: piperine in the supernatant (non-encapsulated)

(2) Reference: Pharmacological and cosmetic properties of piperine.

5 ACCELERATED STABILITY EVALUATION

Accelerated stability was evaluated by centrifugation (LUMISizer®) and calculating instability index (SEPIView™ version 6.4 software).



INSTABILITY INDEX (I)
A dimensionless parameter that combines the extent and rate of particle migration; the higher the value, the less stable the nanoparticle suspension.

Calculated by SEPIView™ software (v6.4) as:
 $I = \frac{\int_0^{H_0} \Delta T(x,t) dx}{H - T_0} \times \frac{1}{T_{end}}$
ΔT(x,t): change in transmittance at height x and time t
H: sample height
T₀: initial transmittance
T_{end}: total experiment time

CONCLUSIONS

Black pepper extracts showed relevant **antioxidant activity** and **high phytochemical content**

Extract-loaded PCL nanoparticles presented suitable **physicochemical properties** and **encapsulation efficiency**

Nanoencapsulation promoted **sustained piperine release** and **good physical stability**

Piperine-loaded nanocarriers represent a promising strategy for **pharmaceutical** and **cosmetic applications**

ACKNOWLEDGEMENTS



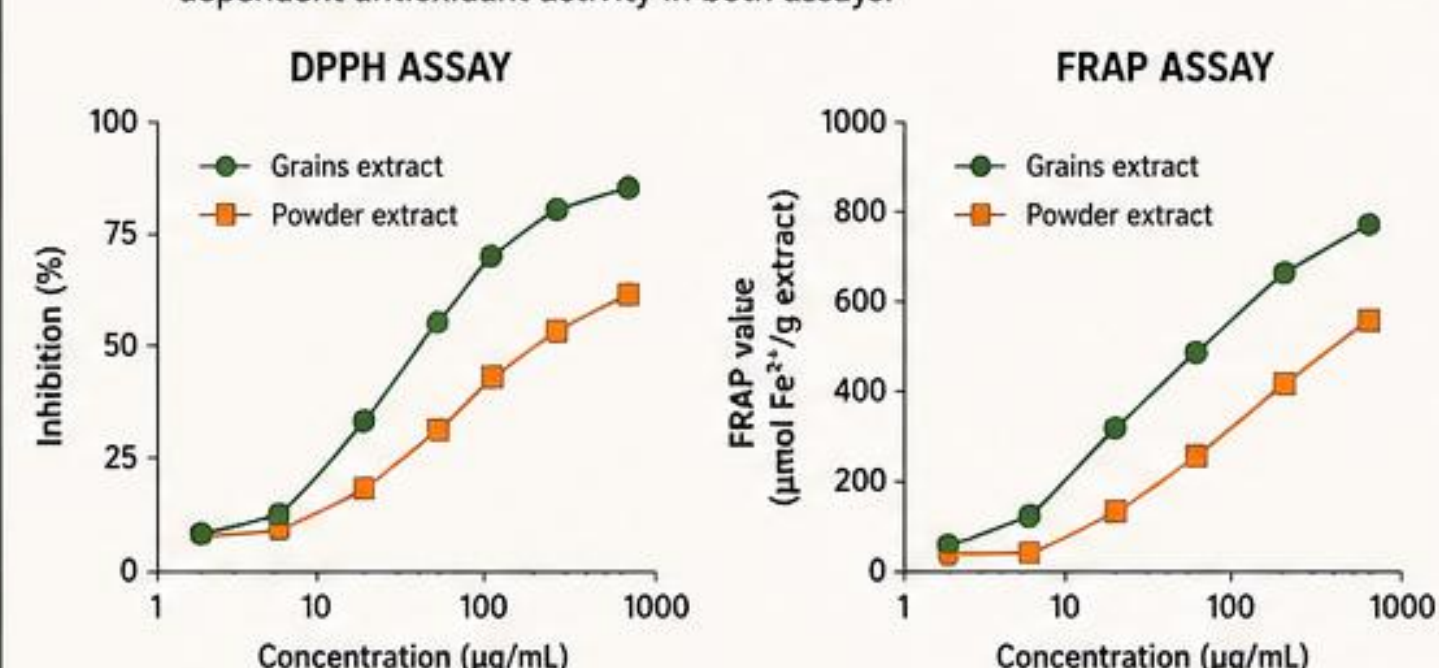
REFERENCES

K. Singletary. Black Pepper: Overview of Health Benefits. Nutr. Today. 45(2010) 43-47.
J.C. Coco, et al. Piperine Extraction and Encapsulation in Polycaprolactone Nanoparticles. Cosmetics. 10(2023) 152.
L.L. Tundisi, et al. Terbinafine Nanohybrid: Proposing a Hydrogel Carrying Nanoparticles for Topical Release. Pharmaceutics. 15(2023) 841.

RESULTS

1 ANTIOXIDANT ACTIVITY

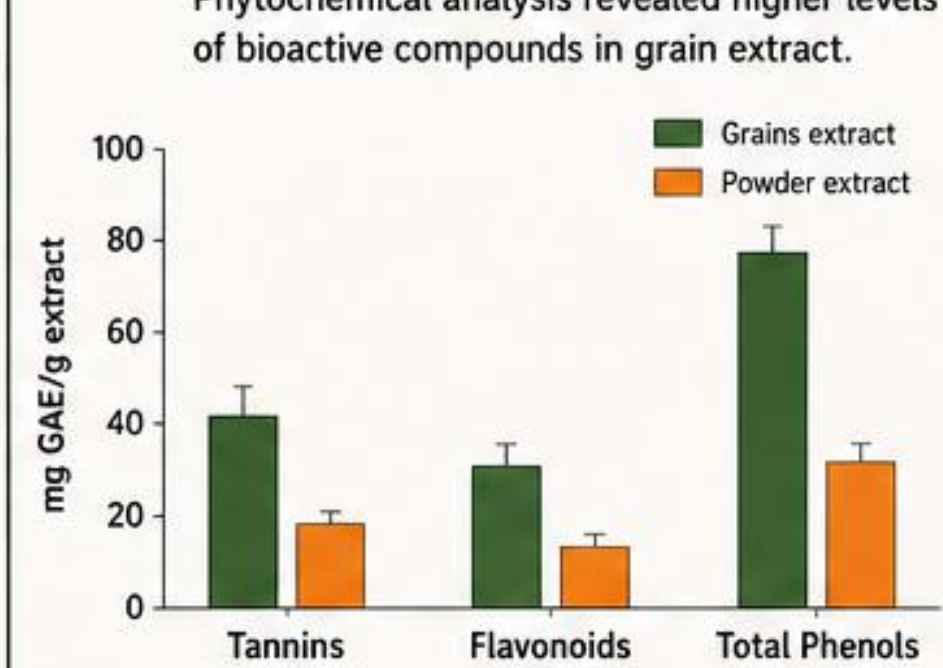
Black pepper extracts from grains and powder exhibited concentration-dependent antioxidant activity in both assays.



Grains extract showed higher antioxidant activity than powder extract in DPPH and FRAP assays. Both extracts presented a dose-dependent increase in antioxidant potential.

2 TANNIN, FLAVONOID AND PHENOL CONCENTRATION

Phytochemical analysis revealed higher levels of bioactive compounds in grain extract.



Grain extract presented significantly higher concentrations of tannins, flavonoids and total phenols compared to powder extract.

3 EXTRACT-LOADED PCL NANOPARTICLES FORMULATION

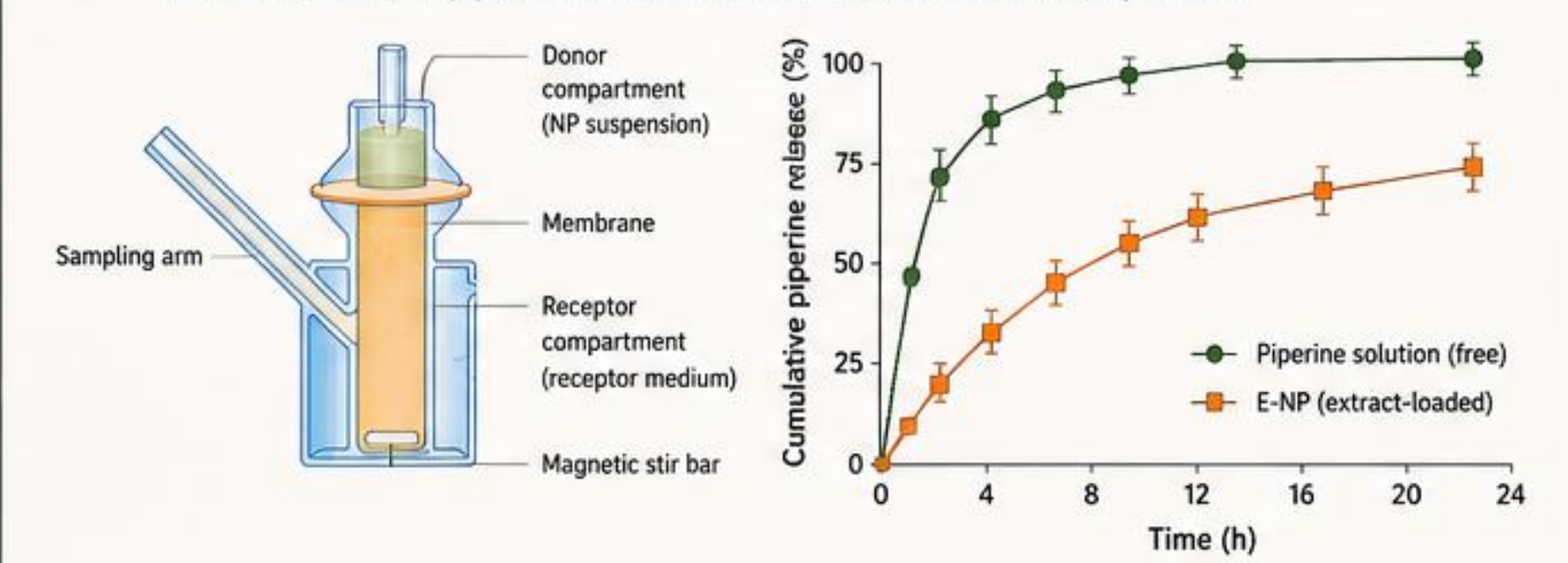
PCL nanoparticles were successfully prepared by nanoprecipitation using PVA as stabilizer.

Parameter	B-NP (Blank)	E-NP (Extract-loaded)
Mean size (nm)	162.3 ± 4.8	178.6 ± 5.7
PDI	0.142 ± 0.03	0.165 ± 0.03
Zeta potential (mV)	-18.7 ± 1.6	-20.3 ± 1.7
Encapsulation efficacy (%)	-	72.4 ± 2.9
Piperine content (µg/mg nanoparticles)	-	8.21 ± 0.35

Nanoparticles showed nanosize, low polydispersity and negative zeta potential. Extract-loaded nanoparticles presented 72.4% encapsulation efficacy for piperine.

4 PIPERINE IN VITRO RELEASE

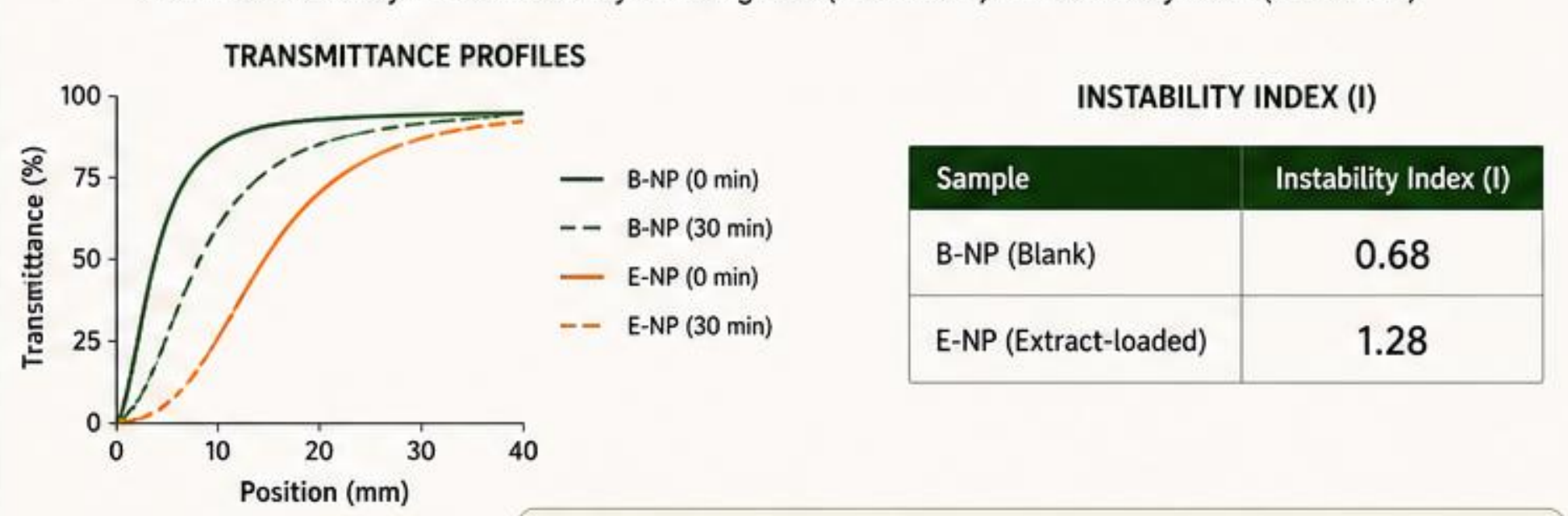
Sustained release of piperine was observed from extract-loaded nanoparticles.



Extract-loaded nanoparticles provided a sustained release profile, reaching ~75% after 24 h, whereas free piperine was completely released within 6 h.

5 NANOPARTICLES STABILITY

Accelerated stability was evaluated by centrifugation (LUMISizer®) and instability index (SEPIView™).



Both formulations remained physically stable under high g-force. Extract-loaded nanoparticles presented a low instability index (I < 2), indicating good stability.