ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb956

# Development and Evaluation of Curcumin–Choline Chloride Ionic Liquid Salt Incorporated into a Self-Microemulsifying Drug Delivery System

Minal Raut[1]; Kajal Bondre[2]; Kirti Charde[3]; Rushika Jaiswal[4]; Ashika Rewatkar[5]; Vaishali Kilor[6]

[1,2,3,4,5,6]Assistant Professor, Adarsh Institute of Pharmacy, Nagpur, Maharashtra, India-440024

Publication Date: 2026/02/28

**Abstract: Curcumin is a bioactive polyphenol with promising therapeutic potential; however, its clinical application is limited by poor aqueous solubility, low stability, and inadequate bioavailability. The present study aimed to enhance curcumin solubility and absorption through ionic salt formation with choline chloride followed by incorporation into a self-microemulsifying drug delivery system (SMEDDS). The synthesized salt showed reduced melting point and improved solubility. The optimized SMEDDS exhibited nanosized droplets, high drug content, and significantly enhanced in vitro drug release and ex vivo permeation compared to plain curcumin. The findings suggest that combining ionic salt formation with SMEDDS technology effectively improves curcumin solubility, stability, and bioavailability.**

***Keywords*** *Curcumin; Choline Chloride; Ionic Liquid Salt; Self-Microemulsifying Drug Delivery System (SMEDDS); Solubility Enhancement; Microemulsion; Dissolution Rate; Bioavailability Improvement.*

**How to Cite:** Minal Raut; Kajal Bondre; Kirti Charde; Rushika Jaiswal; Ashika Rewatkar; Vaishali Kilor (2026) Development and Evaluation of Curcumin–Choline Chloride Ionic Liquid Salt Incorporated into a Self-Microemulsifying Drug Delivery System. *International Journal of Innovative Science and Research Technology*, 11(2), 2022-2027. https://doi.org/10.38124/ijisrt/26feb956

## I. INTRODUCTION

Curcumin, a hydrophobic polyphenolic compound isolated from Curcuma longa, possesses antioxidant, anti-inflammatory, anticancer, and neuroprotective activities[1,2]. Despite its significant therapeutic potential, its clinical use is limited due to poor aqueous solubility, rapid metabolism, low permeability, and extensive first-pass metabolism [2,3].

Several formulation approaches such as nanoparticles, liposomes, phospholipid complexes, and lipid-based drug delivery systems have been explored to overcome these limitations [4,5]. Among these, lipid-based systems such as self-microemulsifying drug delivery systems (SMEDDS) have demonstrated considerable potential in enhancing dissolution and oral bioavailability of poorly water-soluble drugs [6,7].

SMEDDS are isotropic mixtures of oil, surfactant, and co-surfactant that spontaneously form fine oil-in-water microemulsions upon mild agitation in gastrointestinal fluids [6]. The resulting nanosized droplets (<200 nm) increase interfacial surface area and enhance drug dissolution and absorption, often promoting lymphatic transport [7,8].

Ionic liquid salt formation is an emerging pharmaceutical strategy to improve physicochemical properties of active pharmaceutical ingredients (APIs) by reducing crystallinity and enhancing solubility [9,10]. Pharmaceutical ionic liquids and deep eutectic systems based on choline chloride are particularly attractive due to their biocompatibility, low toxicity, and ability to modify melting behavior [11,12].

Therefore, this study aimed to prepare a curcumin–choline chloride ionic salt and incorporate it into a SMEDDS formulation to improve dissolution rate and intestinal permeation.

## II. MATERIALS AND METHODS

➢ *Preparation of Curcumin–Choline Chloride Salt*

Curcumin and choline chloride were mixed in a 1:1 molar ratio in a hydroalcoholic solvent system followed by solvent evaporation. Solvent evaporation and fusion methods are commonly reported techniques for preparing pharmaceutical ionic liquids and eutectic systems [9,10].

➢ *Characterization*

- *UV Spectroscopy*

Curcumin quantification was performed at 425 nm, consistent with reported λmax values in ethanolic systems [13].

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb956

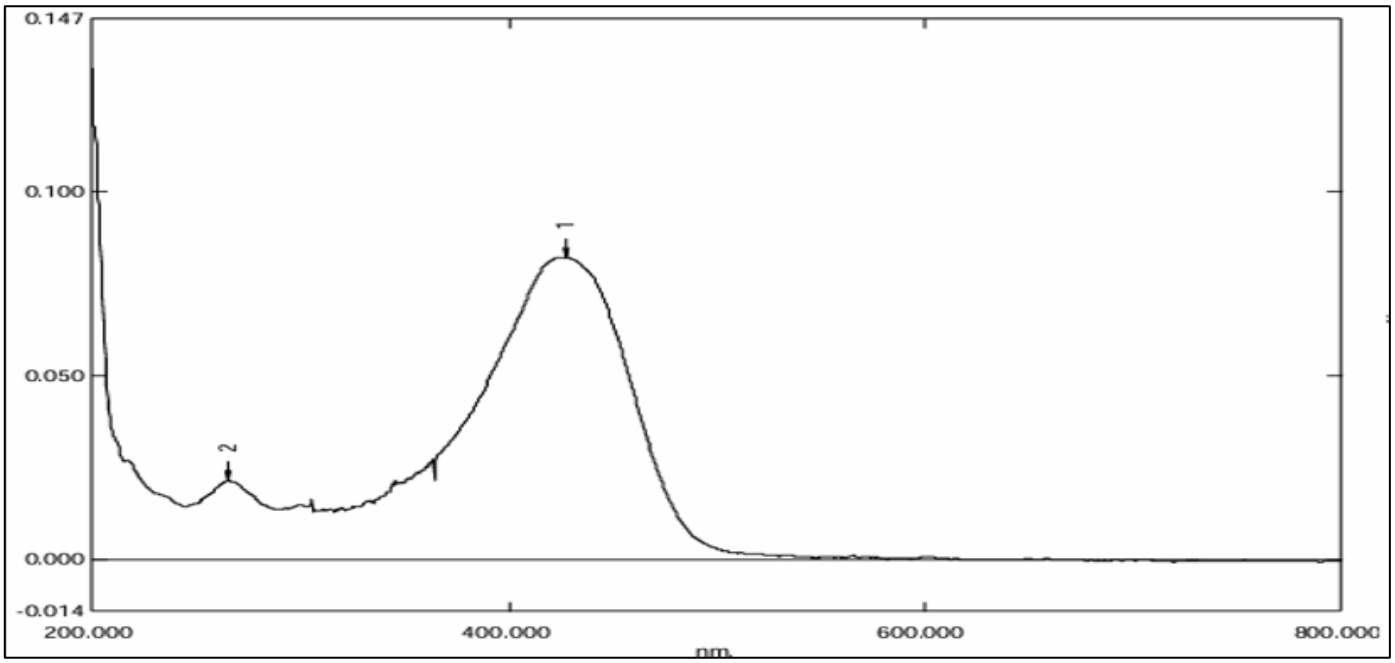


Fig 1 Curcumin Spectra at 425nm

- *Melting Point Determination*

Reduction in melting point is considered an indicator of reduced crystallinity and successful salt formation in ionic liquid systems [9].

- *FTIR Analysis*

FTIR spectroscopy was used to confirm molecular interactions and hydrogen bonding between curcumin and choline chloride, as previously described for API ionic complexes [11]

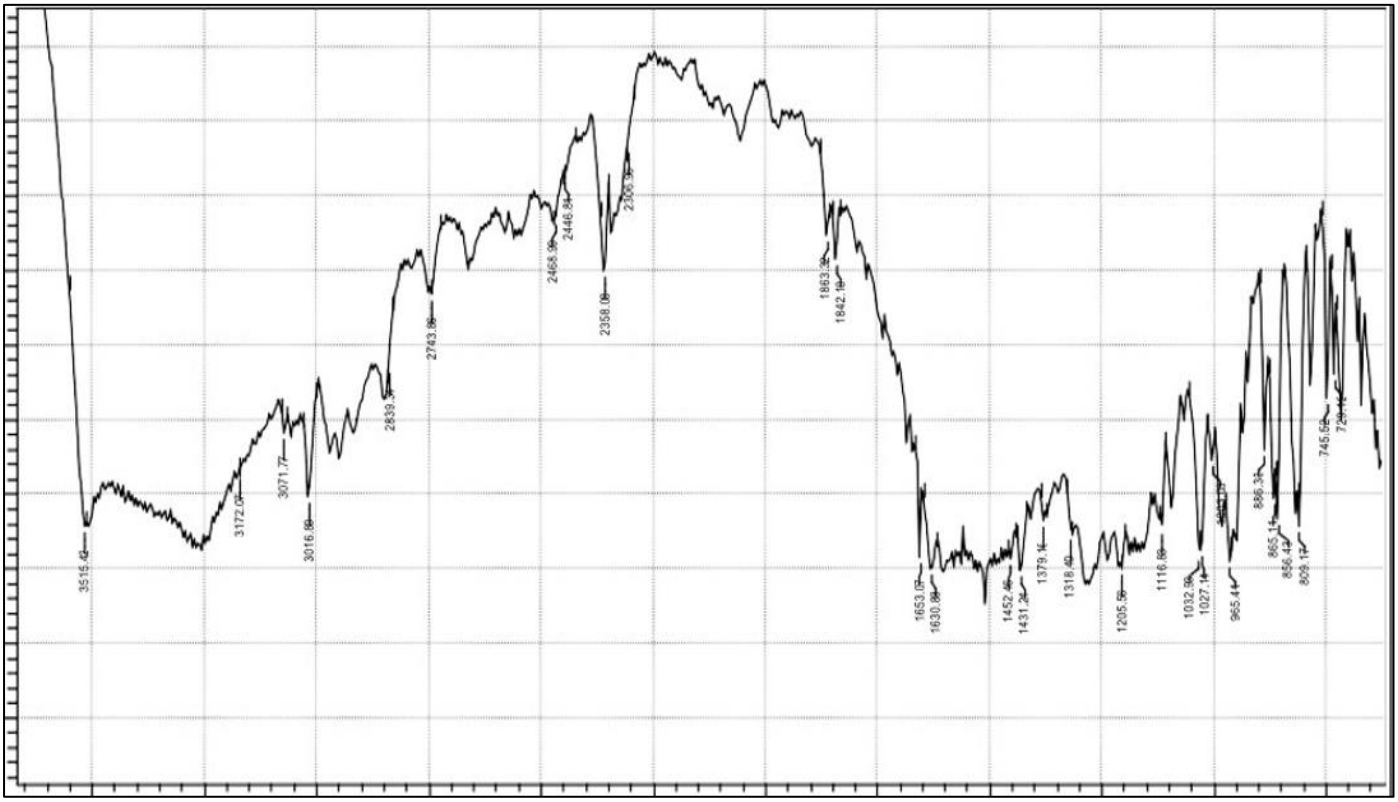


Fig 2 FTIR of curcumin choline chloride salt

➢ *Solubility Studies*

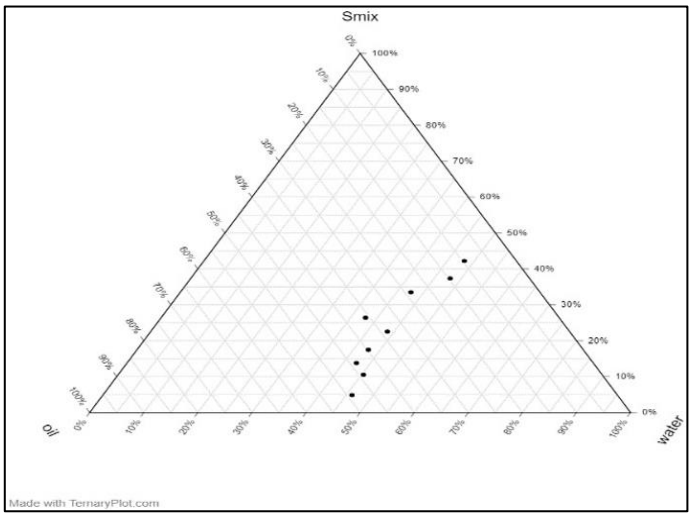
Solubility screening in oils, surfactants, and co-surfactants is a critical step in SMEDDS development and is recommended for rational formulation design [6,14] Excess drug was equilibrated with vehicles, and drug concentration was determined spectrophotometrically.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb956

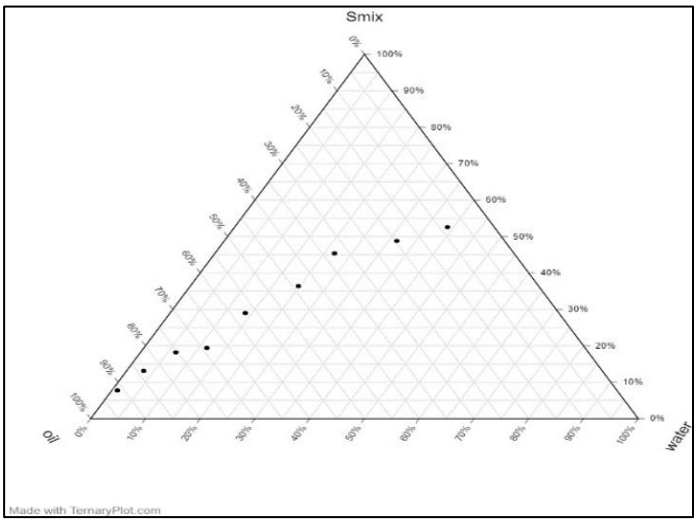

Fig. 3 Solubility study of curcumin choline salt

➢ *Construction of Pseudoternary Phase Diagrams*

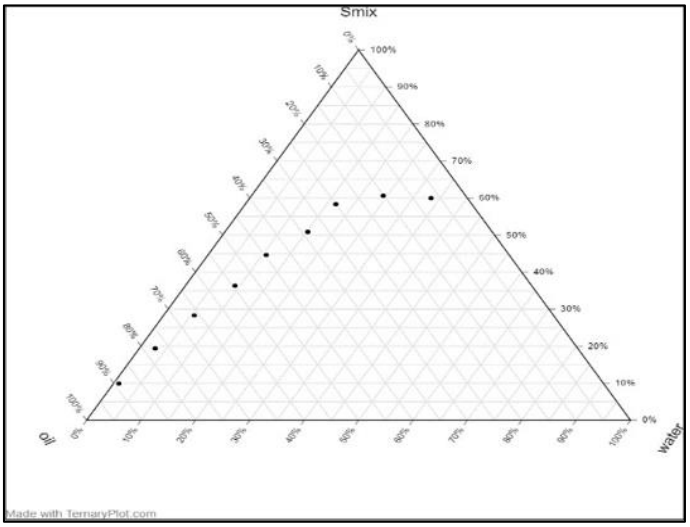
Pseudoternary phase diagrams were constructed using the aqueous titration method to identify microemulsion regions [6,15]. This approach is widely employed to determine optimal surfactant/co-surfactant ratios for microemulsion formation [15].




**1:1 ratio**




**2:1 ratio**




**3:1 ratio**

Fig 4 Pseudoternary Phase Diagram

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb956

➢ *Preparation of SMEDDS*

The SMEDDS preconcentrate was prepared by dissolving the drug in selected oil, surfactant, and co-surfactant mixtures under gentle stirring. Similar preparation methods are commonly reported for lipid-based nanoformulations [7,14].

Table 1 Formulation Batches of SMEDDS

| Excipients | Curcumin choline salts | Turmeric oil | Tween 80 | Ethanol | Total |
|---|---|---|---|---|---|
| Batch 1 | 4 gm | 14.1 gm | 8.6 gm | 2.04 gm | 28.74 gm |
| Batch 2 | 2 gm | 9.57 gm | 7.9 gm | 1.02 gm | 20.49 gm |

## III. RESULT AND DISCUSSION

➢ *Droplet Size and Zeta Potential*

Droplet size and zeta potential were measured using dynamic light scattering. Droplet size below 200 nm are characteristic of stable SMEDDS formulations [6]. A zeta potential value greater than ±30 mV generally indicates good physical stability [16]

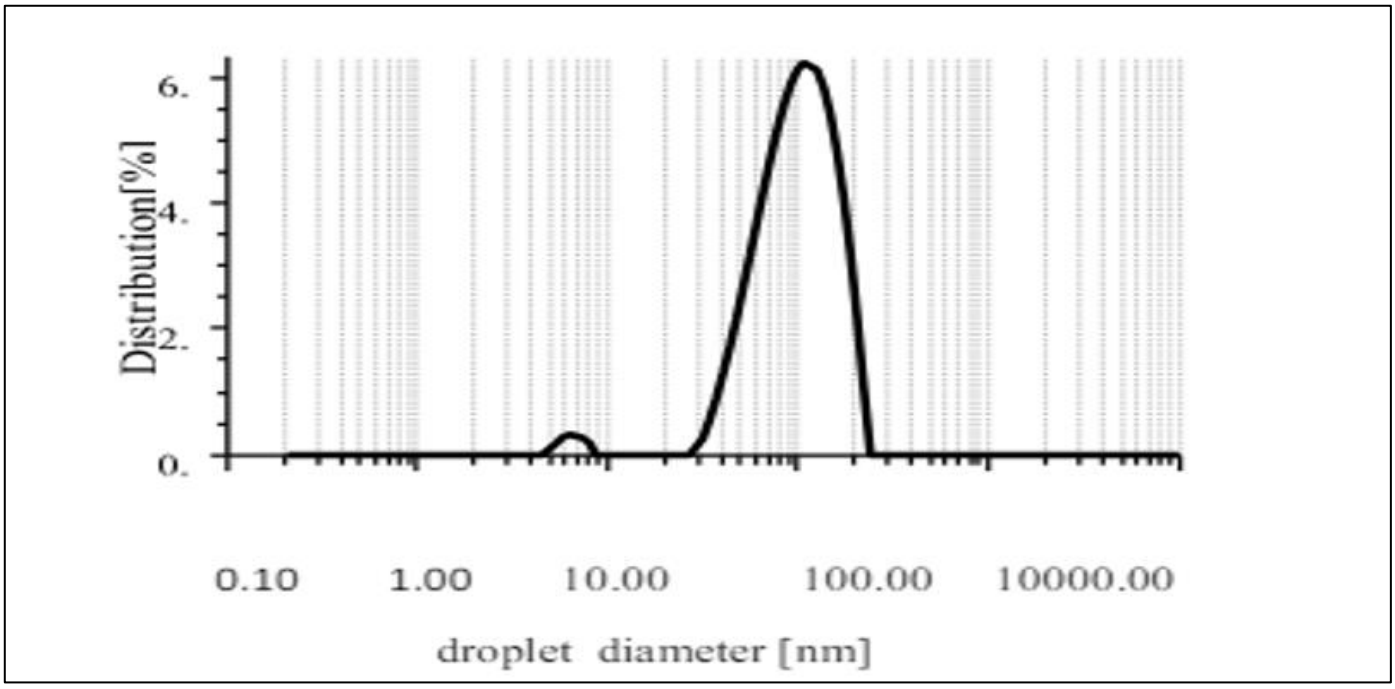



Fig 5 Droplet Size

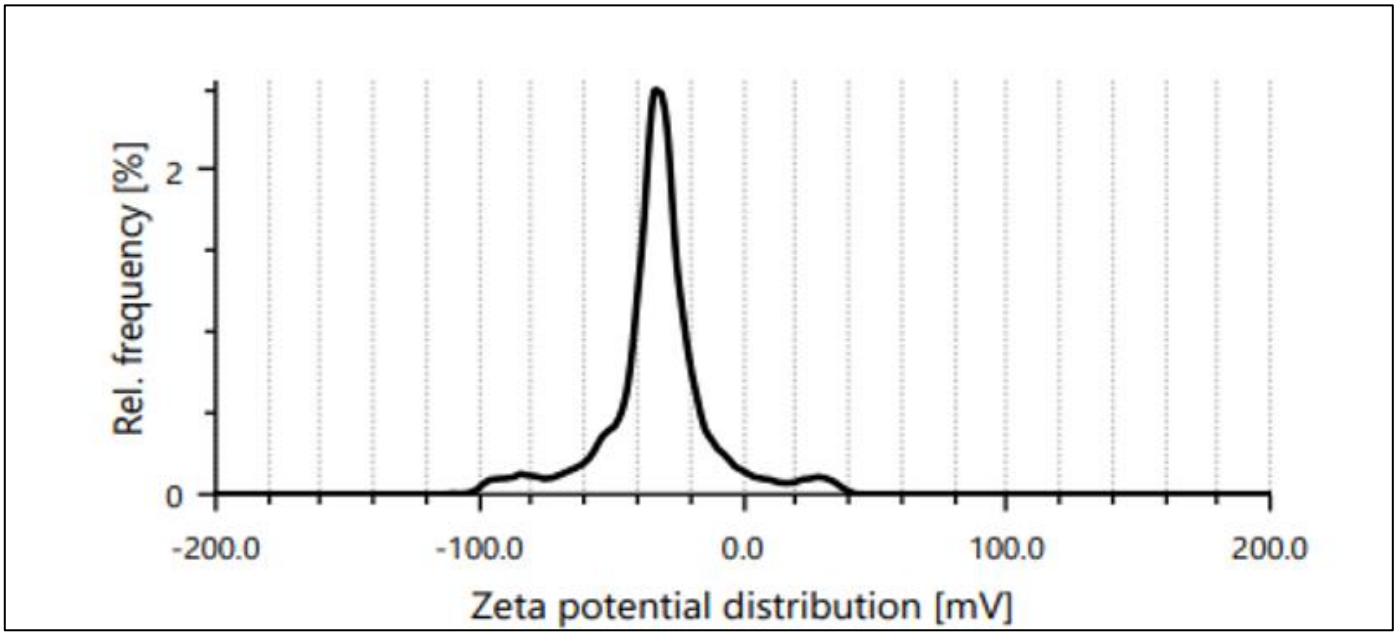



Fig 6 Zeta Potential

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb956

- *Percent Transmittance*

High percent transmittance (>90%) indicates formation of clear microemulsions with uniform nanosized droplets [15]

- *Drug Content*

Drug content uniformity ensures proper incorporation and stability of the drug within lipid systems [7]

- *In Vitro Drug Release*

Dissolution studies were conducted using USP Type II apparatus. Lipid-based formulations are known to significantly enhance dissolution of poorly soluble drugs [7,8].

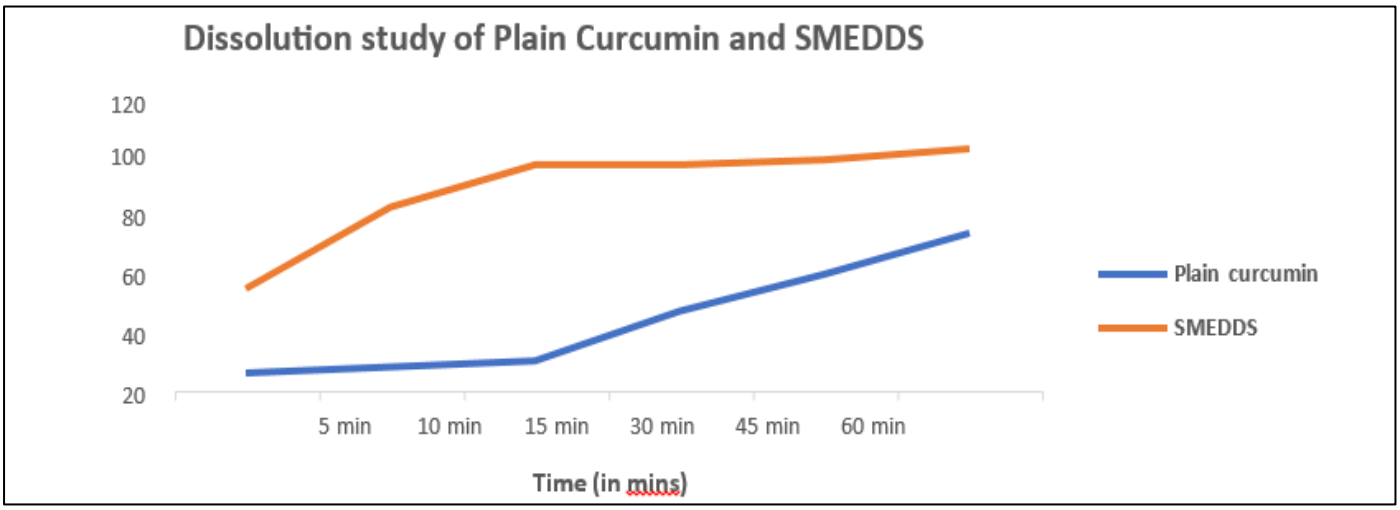



Fig 7 Dissolution Study of Plain Curcumin and SMEDDS

- *Ex Vivo Permeation*

Enhanced intestinal permeation from lipid-based nanoformulations has been attributed to improved solubilization, surfactant-mediated membrane interaction, and possible lymphatic transport [8,17].

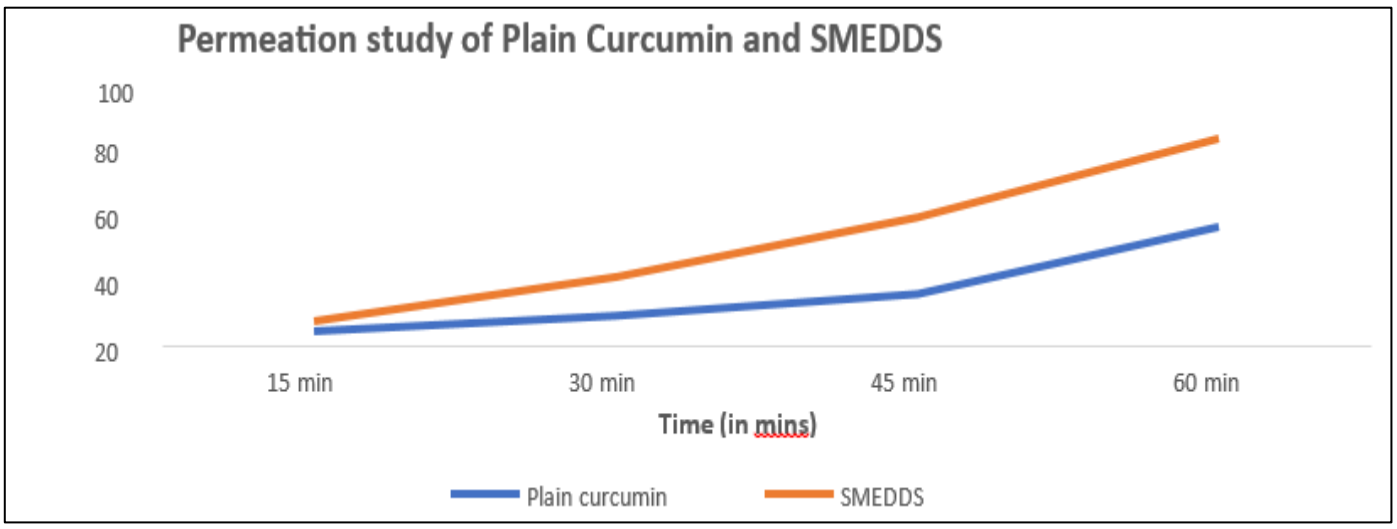



Fig 8 Permeation Study of Plain Curcumin and SMEDDS

➢ *Discussion*

The reduced melting point of the synthesized curcumin–choline chloride salt compared to pure curcumin indicates decreased crystallinity and successful ionic interaction, consistent with previous studies on pharmaceutical ionic liquids [9,11].

The optimized SMEDDS exhibited nanosized droplets (~100 nm), which significantly increase dissolution surface area and drug dispersion [6,7]. The observed negative zeta potential (~−33 mV) suggests good formulation stability [16].

In vitro dissolution studies showed rapid and enhanced drug release compared to plain curcumin, supporting previous findings that lipid-based formulations improve dissolution behavior of lipophilic drugs [7,8].

Ex vivo permeation studies demonstrated significantly higher permeation from SMEDDS compared to plain curcumin, likely due to improved solubilization, membrane interaction, and possible lymphatic uptake [8,17]

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb956

## IV. CONCLUSION

The formation of curcumin–choline chloride ionic salt successfully reduced crystallinity and enhanced solubility. Incorporation into SMEDDS further improved dissolution rate and intestinal permeation. The combined strategy of ionic salt formation and lipid-based microemulsion delivery represents a promising approach to overcome bioavailability limitations associated with poorly water-soluble compounds [7,9]

## REFERENCES

[1]. Aggarwal BB, Sundaram C, Malani N, Ichikawa H. Curcumin: the Indian solid gold. Adv Exp Med Biol. 2007;595:1–75.
[2]. Gupta SC, Patchva S, Aggarwal BB. Therapeutic roles of curcumin. AAPS J. 2013;15:195–218.
[3]. Anand P, Kunnumakkara AB, Newman RA, Aggarwal BB. Bioavailability of curcumin: problems and promises. Mol Pharm. 2007;4:807–818.
[4]. Yallapu MM, Jaggi M, Chauhan SC. Curcumin nanoformulations. Drug Discov Today. 2012;17:71–80.
[5]. Mahran RI, Hagras MM, Sun D, Brenner DE. Bringing curcumin to the clinic. Int J Pharm. 2017;522:1–17.
[6]. Pouton CW. Formulation of self-emulsifying drug delivery systems. Adv Drug Deliv Rev. 1997;25:47–58.
[7]. Porter CJH, Trevaskis NL, Charman WN. Lipid-based formulations and intestinal absorption. Nat Rev Drug Discov. 2007;6:231–248.
[8]. Charman WN, Stella VJ. Transport of lipophilic molecules by intestinal lymphatics. Adv Drug Deliv Rev. 1991;7:1–14.
[9]. Stoimenovski J, MacFarlane DR, Bica K, Rogers RD. Crystalline vs ionic liquid salt forms of APIs. Pharm Res. 2010;27:521–526.
[10]. Hough WL, Smiglak M, Rodríguez H, et al. Ionic liquids as active pharmaceutical ingredients. New J Chem. 2007;31:1429–1436.
[11]. Smith EL, Abbott AP, Ryder KS. Deep eutectic solvents and pharmaceutical applications. Chem Rev. 2014;114:11060–11082.
[12]. Morrison HG, Sun CC, Neervannan S. Characterization of deep eutectic systems. Int J Pharm. 2009;378:136–139.
[13]. Jayaprakasha GK, Rao LJM, Sakariah KK. Improved HPLC method for determination of curcumin. J Agric Food Chem. 2002;50:3668–3672.
[14]. Date AA, Nagarsenker MS. Design and evaluation of self-nanoemulsifying systems. Int J Pharm. 2007;329:166–172.
[15]. Lawrence MJ, Rees GD. Microemulsion-based media as drug delivery systems. Adv Drug Deliv Rev. 2012;64:175–193.
[16]. Honary S, Zahir F. Effect of zeta potential on nanoparticle stability. Trop J Pharm Res. 2013;12:255–264.
[17]. Constantinides PP. Lipid microemulsions for improving oral absorption. Pharm Res. 1995;12:1561–1572.