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Short communication

Preliminary investigation of the phase behavior of systems containing black cumin seed oil, nonionic surfactants and water

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Introduction

Plant-derived oils are very complex mixtures of compounds from different classes, which possess physiological and/or therapeutic effects, acting alone or in synergy with other ingredients to prevent or treat various diseases. Therefore, nowadays an increasing interest in bioactive plant-derived oils is granted by formulators in pharmaceutical domain to develop appropriate systems for their delivery as such or in combination with chemical drugs (Dincheva et al., 2023; Masiero et al., 2021).

Recently, among the formulation strategies referring topical carriers, emulsions and microemulsions provide a rational approach for designing promising bioactive plant-derived oils delivery systems for topical application (Xavier-Junior et al., 2017).

Due to its bioactive components, black cumin seed oil (BCO) demonstrated effectiveness in different skin problems (i.e. atopic dermatitis, eczema, psoriasis, vitiligo, urticaria, and acne), having antimicrobial, anti-inflammatory, and wound healing properties (Ketenoglu et al., 2020; Nasiri et al., 2022].

This study aimed to investigate the phase behavior of black cumin seed oil in association with different hydrophilic non-ionic surfactants, cosurfactants and water, using pseudo ternary phase diagrams, in order to identify microscopic emulsion-like structures, including microemulsion (ME), emulsion (E) and corresponding gel phases (MEG and EG), as potential carriers for skin application of pure black cumin seed oil or in combination with poorly water soluble drugs.

Materials and methods

Black cumin seed oil was supplied by SC Solaris Plant SRL (Romania); surfactants PEG-40 hydrogenated castor oil (HLB 14-16) and PEG-35 castor oil (HLB 13) were kindly donated by BASF Chem Trade GMBH (Germany), and polyoxyethylene-20 sorbitan monolaurate (HLB 16.7), polyoxyethylene-20 sorbitan monooleate (HLB 15) and polyoxyethylene-23 lauryl ether (HLB 16.9) were purchased from Sigma-Aldrich (Germany); cosurfactants isopropanol, n-butanol and n-pentanol were supplied by Chemical Company S.A. (Romania), Sigma-Aldrich (Germany) and respectively Carlo Erba (Italy); puriffied water was used throughout the study. For the construction of pseudoternary phase diagrams (PTPDs), a novel technique based on water titration method was used, namely the micro-plate dilution method (Schmidts et al., 2009)

Results and discussion

In the PTPDs of ternary systems containing surfactant-cosurfactant mixture (Smix) in fixed weight ratio of 1:1, clear (transparent) ME and/or milky-white emulsion regions were delimited; the surfactants PEG-35 castor oil and PEG-40 hydrogenated castor oil mixed with n-

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pentanol produced the largest ME regions, 26.10% and 26.94% respectively; for the Smix containing isopropanol, only E regions resulted, excepting that of PEG-40 hydrogenated castor oil, which produced an extremely small ME region (0.42%) (Fig. 1). These results indicated that the area of ME region increased as the cosurfactant lipophilicity and chain length increased (n-pentanol>n-butanol>isopropanol), most probably because it is less active than surfactant in the interfacial film.

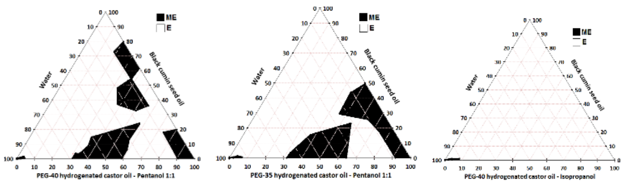

Fig. 1. PTPDs of ternary systems composed of black cumin seed oil, surfactant (PEG-40 hydrogenated castor oil or PEG-35 castor oil), cosurfactant (pentanol or isopropanol) and water at Smix 1:1

In comparison with the case of Smix 1:1, the PTPD constructed for Smix PEG-40 hydrogenated castor oil-pentanol and PEG-35 castor oil-pentanol in 2:1, 3:1, 4:1 and 5:1 ratios, revealed the existence of larger ME regions (37.93-50.0 % respectively 34.32-40.93 %) and of MEG and EG phases (Fig. 2).

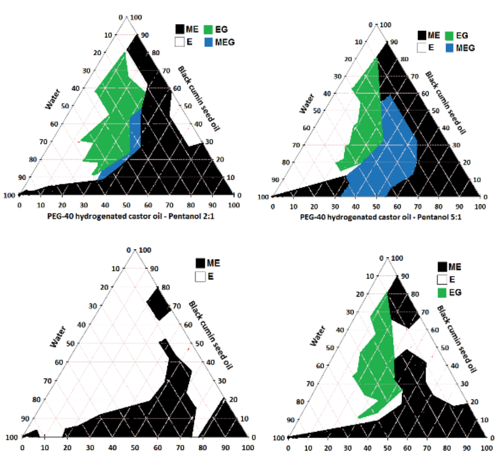

Fig. 2. PTPDs of ternary systems composed of black cumin seed oil, surfactant (PEG-40 hydrogenated castor oil or PEG-35 castor oil), cosurfactant (pentanol) and water at Smix 2:1 and 5:1

Different ability of the tested surfactants to solubilize black cumin seed oil in the presence of a cosurfactant from the category of short-chain alcohols can be attributed to the HLB value closely correlated with their chemical structure and the chemical composition of the tested oil.

Conclusion

The study revealed the following aspects: a) among the cosurfactants used, pentanol achieved the largest microemulsion regions; b) all three tested cosurfactants were more effective in combination with macrogol-40-glycerol-hydroxystearate in generating larger micro-emulsion regions, than when combined with the other tested surfactants; c) for black cumin seed oil, the surfactant PEG-40 hydrogenated castor oil shows a better microemulsification capacity, especially in the presence of pentanol as a cosurfactant at ratios of 3:1, 4:1 and 5:1 Smix.

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