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Short communication

A brief review of curcumin loaded nanoparticles

Elena Drakalska Sersemova[1*], Tamara Tashkov[2], Dijana Miceva[1], Elena Joveva[2], Ljubica Adji Andov[3]

[1]*Faculty of Medical Sciences, University "Goce Delcev" – Stip, Krste Misirkov 10-A, 2000 Stip, N. Macedonia*
[2]*Clinical Hospital-Shtip, Ljuben Ivanov 25, 2000 Stip, N. Macedonia*
[3]*Synlab-Skopje, Anton Popov 1lok. 3, 4, 5 MK, 1000 Skopje, N. Macedonia*

Introduction

Curcumin, the yellow extract derived from the plant Curcuma Longa, exhibited numerous therapeutic applications against wide range of chronic diseases such as diabetes, pancreatitis, arthritis, neurodegenerative diseases and various types of cancer. The first isolated curcumin was generated in 1815, from the rhizome of Curcuma longa L. by Vogel and Pelletier, and in 1910 it was identified as dipheruloilmethane [1,7-Bis(3-methoxy-4-hydroxyphenyl)-1,6-heptadiene-3,5-dione], classified in the group of polyphenol compounds (Lampe et al., 1913). The main mechanism of curcumin pharmacological activity inhibition of nuclear factor κB (NFκB), connected with expression and regulation of various genes implicated in tumor biology of different malignances like colon cancer, leukemia, multiple myeloma etc. Unfortunately, the therapeutic potential of curcumin cannot be exploited due to low water solubility (11 ng/ml), extremely low systemic bioavailability after oral administration (8 g/day) and impossibility to achieve the therapeutic concentration. Consequently, curcumin shows significant presystemic biotransformation, mainly via glucuronide and sulfate conjugation (Priyadarsini, 2009).

Materials and methods

The purpose of this paper is to review the structure of the different types of nanoscale systems as platforms for delivery of curcumin, such as liposomes, solid lipid nanoparticles and cyclodextrines. Also, we evaluated the role of the components in their structure and detected the factors that affected the stability of nanoparticles. Our research was focused on comparison of clinical trial results regarding efficacy and bioavailability of encapsulated curcumin. To accomplish these goals, we used data from relevant literature sources from primary, secondary and tertiary literature, with emphasis on original scientific research. We systematized the summarized literary data according to the actual treatment of the problem, noted the formulation aspects by using different methods of preparation, and identified the advantages and disadvantages by highlighting the possibilities of optimizing the therapy of various diseases.

Results and discussion

One of the most promising classes of nanoscale carriers for delivery of curcumin are liposomes. They represent highly-organized spherical structures, consisting of concentrically situated phospholipid bilayers (lamellas) including water volume, between them, and also in the central cavity. Liposomes were discovered in 1961 by Bangham (Liu et al., 2022). Their size ranges from 20 nm to several μm, whereas the thickness of the membranes from 4 to 7 nm. The liposomes possess unique characteristics, owing to the amphiphilic character and low toxicity, which makes them suitable for encapsulation of, both, hydrophilic and lipophilic substances. However, the route of administration and also the encapsulation efficiency of curcumin are highly dependent of type of phospholipid in the liposome (Andra et al., 2022). The most often used constituents of liposomal membrane are natural phospholipids or lipids such as 1,2-dipalmitoyl-sn-glycero-3-phosphatidyl choline (DPPC), 1,2-distearoryl-sn-glycero-3-phosphatidyl choline (DSPC), egg

*elena.drakalska@ugd.edu.mk

phosphatidyl choline (EPC),dimyristoylphosphatidyl choline (DMPC), soybean phosphatidylcholine (SPC), hydrogenated soybean phosphatidylcholine (HSPC) etc. and cholesterol. Encapsulation of curcumin into liposomes showed dose dependent increment of fraction of apoptotic cancer cells and suppression of the activity of the NFκB (Amekyeh, H et al., 2022). However, one of the main technological problems, limiting the clinical realization of liposomal curcumin is the low entrapment capacity, owing to the localization of the curcumin molecules primarily in phospholipid membranes, associated with membrane disintegration above certain concentration. One of the approaches to improve the poor aqueous solubility and instability as well as to prolong the cytotoxic activity of curcumin is the encapsulation into solid lipid nanoparticles (SLNs). The solid lipid nanoparticles are aqueous dispersions in which the liquid oil is substituted with a solid biocompatible and degradable lipid matrix (Wang et al., 2018). They are characterized with higher stability (as compared with liposomes), tolerance and ability of encapsulation. Curcumin as a free powder and incorporated in solid lipid nanoparticles was tested as a chemopreventive agent topically administrated in mice with induced skin cancer. The results indicated significant reduction of malondialdehide by curcumin loaded nanoparticles than in mice treated with free curcumin (Kaur et al., 2013). A recent study has shown that the brain delivery of curcumin loaded SLN is improved, proved by enhanced cognition and acetylcholine esterase inhibition in rats with cerebral ischemia, associated with significant increment of the level of different enzymes such as glutathione, superoxide dismutase, catalase and mitochondrial complex enzyme (Del-Prado et al., 2019). An interesting method of optimization of the systematic delivery of curcumin was its inclusion in cyclodextrins. Cyclodextrins are one of the most researched macro-cycle cavitants. They represent cyclic oligosaccharides, consisting of D-(+) glucopyranose units, linked through α-(1, 4) glucosidal linkages. Depending on the number of the glucopyranose residues in the molecules, cyclodextrins are divided into three groups: α, β and γ-cyclodextrins containing respectively 6, 7 and 8 glucopyranose units. Rachmawati et al. showed that complexes of curcumin with β-cyclodextrin were characterized with two-fold higher transdermal permeability in comparison to free curcumin. Antiproliferative and anti-inflammatory activity of the curcumin as a result of suppression of the THF-induced activation of NF-κB was significantly higher in curcumin, included in cyclodextrins in comparison with the free agent.

Conclusion

A variety of lipid based nanocarriers such as solid lipid nanoparticles, liposomes and cyclodextrins described in this review show a profound improvement of the pharmacokinetic profile of curcumin. However, to translate curcumin nanoformulations as drug candidate allowing full utilization of its therapeutic potential, future pre-clinical and clinical investigations in depth are required.

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