Project-Based Learning: Enhanced Drug Delivery Through Micelle-Turmeric Complex

Department of Chemistry
Jamie Grady, Cortney Taylor, Taylor Wilson
Faculty Advisor: Dr. Tolulope Salami

Highlighted in this poster is a proposal developed in the Project-Based Learning (PBL) Biomaterials course where we are required to identify a problem (disease/condition) and suggest a bioactive device/material with potential to solve that problem. An integral component of many traditional approaches to medicine is the regular ingestion of certain plants. One such medicinal plant is the rhizome of Curcuma longa (turmeric). Research has shown that the phytochemical curcumin may act as a powerful anti-inflammatory, especially when in combination with a phyto-alkaloid, piperine. The anti-inflammatory properties of curcumin paired with piperine makes this complex a strong candidate for an array of potential clinical applications. One of the main hindrances in the controlled delivery of curcumin is a low degree of water-solubility, so this proposal involves increasing the solubility and bioavailability by encapsulation. This proposal has the potential to reduce systemic inflammation in the brain.

Introduction

Infectious diseases and deaths have recently declined; however, many chronic diseases are on the rise. A common biological phenomenon related to many chronic diseases is a persistent degree of systemic inflammation. This low-level, systemic inflammation is currently being researched with intent to develop proposals to address this issue. Using curcumin complexed with piperine to combat systemic inflammation is a highly researched procedure. The low degree of water solubility of this complex presents an issue with clinical applications. Encapsulation of the organic molecules into a micelle may well serve as an effective drug delivery system, as this method has been successfully applied before. The fatty acid, Docosahexaenoic acid (DHA), is well understood to mediate and undergo passage of the blood brain barrier, and could effectively serve as a carrier molecule for the organic complex. Upon arrival into the brain, the DHA micelles should spontaneously undergo degranulation, thus releasing the curcumin/piperine complex. Curcumin, piperine, and DHA are affordable, renewable, and free of known adverse side effects.

Proposed Formulation and Materials

Micelle formation is often a spontaneous process, but the encapsulation of curcumin is not expected to be 100% (total encapsulation). Encapsulation Efficiency (EE) is the percentage of a molecule or drug that is effectively encapsulated in a nanoparticle.

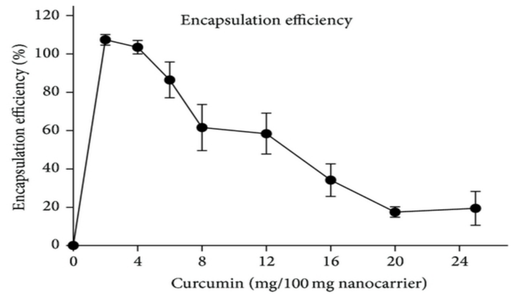

Figure 1. This graph shows EE versus increasing concentration of curcumin relative to constant 100 mg of the carrier, where DHA is used in this proposal. Based on this data, curcumin is most efficiently encapsulated around 4 mg per 100mg of DHA.

Proposed Bioavailability Verification

The complexes formed will be diluted with HPLC grade methanol and analyzed via HPLC at regular intervals to ensure a high degree of stability, thus ensuring a marketable product. The realization that an unstable product is not marketable will serve as a driving force behind extensive biocompatibility testing measures.

Proposed Delivery Mechanism

DHA mediated passage of the blood brain barrier, BBB, is a thoroughly researched phenomenon. The fact that DHA easily gains passage to the brain makes it a suitable carrier molecule for desirable therapeutics that would otherwise remain outside of the brain. DHA is metabolized by various brain cells once past the blood brain barrier, thus releasing encapsulated curcumin/piperine complex. Once curcumin and piperine are on site, they can assume their anti-inflammatory role.

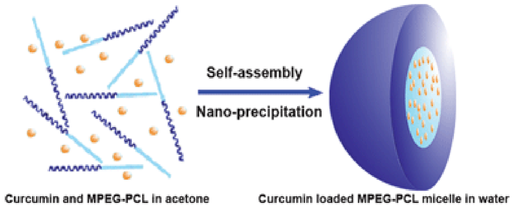

Figure 2. This visual scheme shows self-encapsulation of in the curcumin/piperine complex with the DHA nanocarrier. Encapsulation of available curcumin and piperine molecules should be spontaneous and display a high EE when in solution containing: 60% methanol, 10% DHA phospholipids, and 30% water.

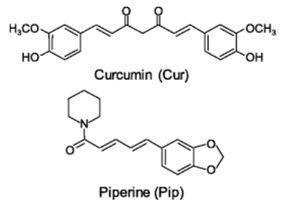

Figure 3. Skeletal molecular models of both micelle components.

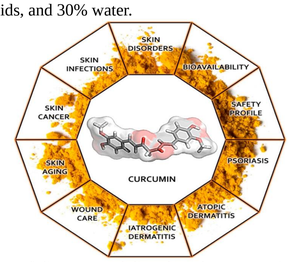

Figure 4. Array of diseases and disorders that curcumin is known to treat.

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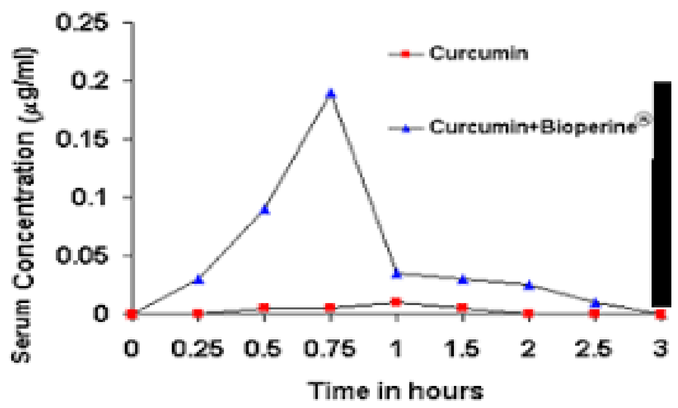
Proposed Date



ABOVE- Data illustrating the degree to which curcumin bioavailability increases with presence of piperine

References

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Conclusion

A holistic approach to health and wellbeing does not have to be independent of medical technologies yielded from decades of rigorous medical research.. History has proven that many plants possess medical capabilities, and the drug delivery system technologies developed over time have yielded new ways to deliver therapeutic plant compounds into the inflamed body. This example of fusion of traditional medicine and modern medical technology is a cornerstone of Integrative Medicine.

Curcumin, piperin, and DHA are :

Affordable

Renewable

Free of known adverse side effects

Biologically active with extensive research to document implications on health and disease

Environmentally friendly

Whole-food sourced

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