3D Printed Biodegradable Implants Loaded with Capsaicin for the Treatment of Obesity and its Related Health Risks

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Obesity increases the risk of various health complications, including type 2 diabetes, hyperlipidemia, and cardiovascular disease.[1] The current FDA-approved drug therapies designed to combat obesity are limited and known to have severe side effects. Therefore, there is an urgent need to develop natural drug therapies with reduced side effects.

Research studies have shown that capsaicin, the primary ingredient in chili peppers, is effective in promoting weight loss and reducing obesity-related health conditions.[2] The anti-obesity effects of capsaicin have previously been studied in animal and human models; however, these studies were conducted by administering the drug orally.[3] Oral administration cannot be sustained long-term due to the pungency and poor oral bioavailability of capsaicin. This research project aimed to identify an alternative delivery method for capsaicin.

Through an extrusion-based 3D printing method, biodegradable implants were designed to potentially deliver capsaicin directly to the fatty tissue for a prolonged period. Since the implants will be inserted directly under the skin to access the fat regions, the sustained release aspect is vital to reduce the need for multiple invasive procedures and medical appointments. The 3D printing technology may also improve the treatment process as it allows for personalized dosage forms that best fit the needs of clinical patients.

The Cellink BIOX 3D printer prepared the rod-shaped implants through a direct powder extrusion-based printing method. This single-step method allows a blend of the drug and polymer to be inserted directly into the printer, eliminating the need for any initial manipulation. As shown in Figure 1, the drug-polymer blend is melted within the print head and extruded through a nozzle layer by layer due to the application of high pressure.[4] The final product is depicted in Figure 2.

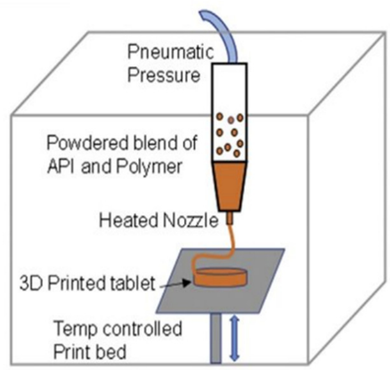

Fig. 1 Schematic of extrusion-based 3D printing method.

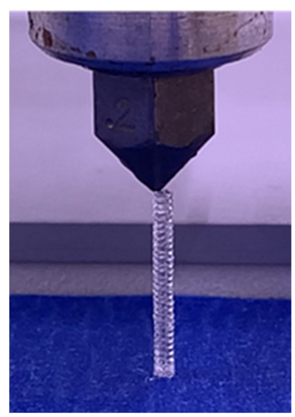

Fig. 2 Rod-shaped implant loaded with capsaicin being extruded from the 3D printer nozzle.

The polymer used in creating the implants was chosen for its biodegradable properties and wide usage in controlled release medical devices. Several parameters, including pressure, nozzle diameter, and print bed temperature, were optimized to ensure the implants were well-formed and of the highest quality possible. To maintain the thermal stability of the drug, the printing temperature was optimized to 180°C.

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Several studies were conducted to investigate the chemical and physical properties of capsaicin within the implants. An assay was performed to measure the total drug content within each implant, ensuring that the drug maintained thermal stability during the printing process and the drug content of each implant was uniform. To assess the long-term sustainability of capsaicin, an *in vitro* release study was conducted to measure the duration of drug release from the implants under static conditions. A stability study was conducted to ensure the drug remained stable over time under exposure to extreme temperatures. A forced degradation study was conducted to investigate the rate of drug degradation under various chemical conditions.

Overall, the results from this research will determine if 3D-printed devices may be helpful in the site-specific administration and sustained release of capsaicin. Once the implants are thoroughly studied and characterized, the devices will be inserted subcutaneously in a high-fat mouse model to further investigate the effects of capsaicin on diet-induced obesity. All data and findings will be presented in a peer-reviewed journal once this research project is complete.

Statement of Research Advisor

Jessica Heard has significantly contributed to current ongoing research on capsaicin implants preparation and characterization. She has performed experiments daily and generated data on capsaicin stability and release from the implants.

- *Jayachandra Babu Ramapuram, Department of Drug Discovery and Development, Harrison College of Pharmacy*

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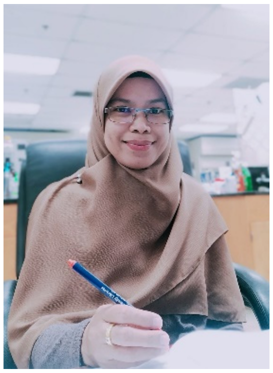
Authors Biography

Jessica Heard is a senior-year student pursuing a B.S. degree in Biochemistry at Auburn University. As the 2022 undergraduate research fellow, she has played key research roles in the studies related to capsaicin loaded 3D-printed implants.

Manjusha Annaji is a Ph.D. student at Auburn University, working under the guidance of Dr. Jay Ramapuram. Her research focuses on the fabrication of different 3D printed dosage forms such as orodispersible films, polypills, and polymeric implants for treating various chronic diseases. She is the creator of capsaicin loaded 3D-printed implants and provided the research protocols.



Nur Mita is a Ph.D. student at Auburn University, working under the guidance of Dr. Jay Ramapuram. Her works focus on developing intravenous injections, 3D printed-orodispersible films, and in situ forming implant formulations. She served in the supervisor role and has provided daily guidance on the stability and drug release studies and assisted in data curation and presentation.

Dr. Jayachandra Babu Ramapuram, Professor, Department of Drug Discovery and Development, Harrison College of Pharmacy, Auburn University, is the research mentor. He is involved in conceptualization, study design, and data analysis.