OPTIMIZATION AND CHARACTERIZATION OF 3D PRINTED SOLID ORAL DOSAGE FORMS

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Abstract

This research focuses on the dosage, characterization, and standardization of three-dimensionally printed pharmaceutical tablets. The study establishes the methods, parameters, and formulations necessary for the bio-ink used in the printing process. A calibration curve was developed and validated using a UV-Visible Spectrophotometer to quantify the uniformity of caffeine content in the tablets. These results demonstrate that the uniformity of tablets produced through 3D printing is superior to those manufactured using traditional pharmaceutical methods. Future work should focus on evaluating the tablets' hardness, disintegration, and friability to further assess their quality.

Introduction

Additive manufacturing, defined as the production of detailed parts in three dimensions through a layer-by-layer process, represents one of the most recent advancements in manufacturing technologies. Nearly two decades ago, this technology emerged as the "rapid prototyping process," which enabled layer-by-layer modeling (Ortiz, 2023). Today, additive manufacturing, or 3D printing, is recognized for its capability to produce small, detailed parts or physical products from digital data, forming objects with precision and complexity. A novel application of additive manufacturing is the production of pharmaceutical tablets. This approach allows for the creation of oral solid dosage forms while ensuring content uniformity and reliability in tablet characteristics. Consequently, the primary focus of this investigation was to achieve an optimal tablet printed using 3D-printing technology. To achieve this objective, design tools such as TinkerCad® and the Ultimaker Cura® fine-tuning program were employed to precisely configure slicing and tablet printing parameters.

As part of this study, tablet design, bioink preparation, printing parameters, and drying conditions were tested and optimized to develop a pharmaceutical tablet that met the desired specifications.

For the bioink, potato and corn starch were evaluated, while for the API (Active Ingredient Active) caffeine was selected as an optimum ingredient.

Objectives

- Evaluation of Excipients and Active Pharmaceutical Ingredients
- Standardization of the preparation process of the bioink.
- 3D-Printing parameters optimization.
- Selection of drying parameters.
- Evaluation of pharmaceutical tablets produced by Bioprinting.

Methodology

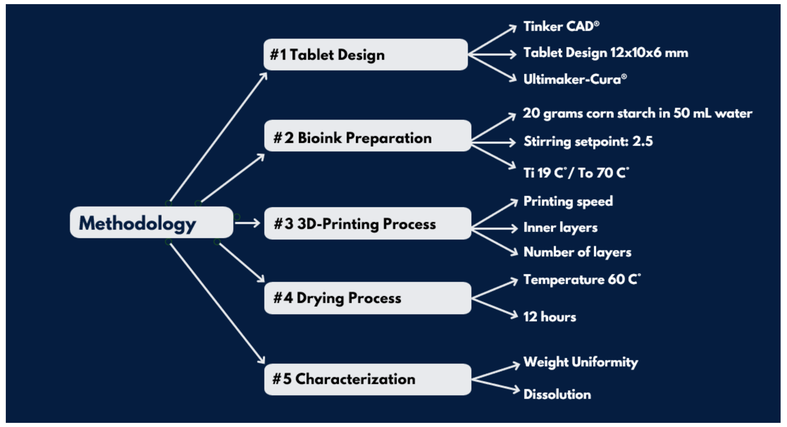

Figure 1: Tablet Preparation and 3D Printing Process Flow Chart

Figure 2: Schematic Representation of the Tablet Manufacturing Process

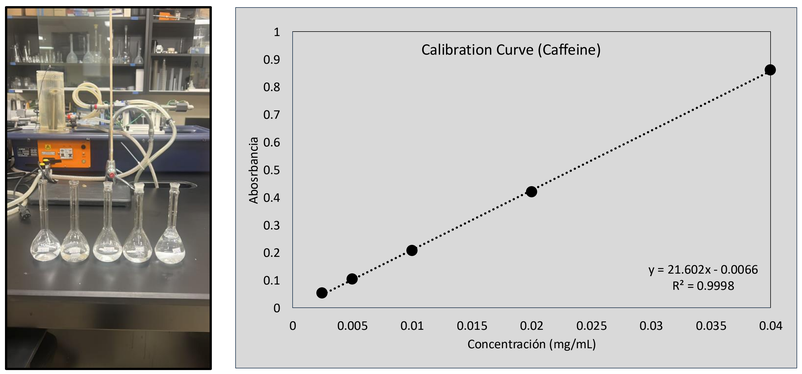

Figure 3: Standard Solutions and Calibration Curve of Caffeine

Data

Tablet	Weight (mg)	Absorbance	Caffeine (mg) tablets	Concentration (%)
1	251.7	0.22	5.2449	2.08
2	238.0	0.188	4.5042	1.89
3	223.2	0.164	3.9487	1.77
4	234.7	0.2	4.7820	2.04
5	229.0	0.175	4.2033	1.84
6	234.7	0.219	5.2217	2.22
7	214.7	0.14	3.3932	1.58
8	230.5	0.166	3.9950	1.73
9	240.2	0.169	4.0644	1.69
10	241.8	0.185	4.4348	1.83
11	248.0	0.153	3.6941	1.49
12	249.1	0.174	4.1802	1.68
13	248.2	0.169	4.0644	1.64
14	247.0	0.285	6.7494	2.73
15	245.6	0.326	7.6984	3.13
16	247.1	0.315	7.4438	3.01
17	241.6	0.271	6.4253	2.66
18	246.6	0.325	7.6752	3.11
19	242.3	0.289	6.8420	2.82
20	240.9	0.318	7.5132	3.12

Table 1: Weight, Absorbance, and Caffeine Concentration in 3D-Printed and Compressed Tablets

Analysis and Results

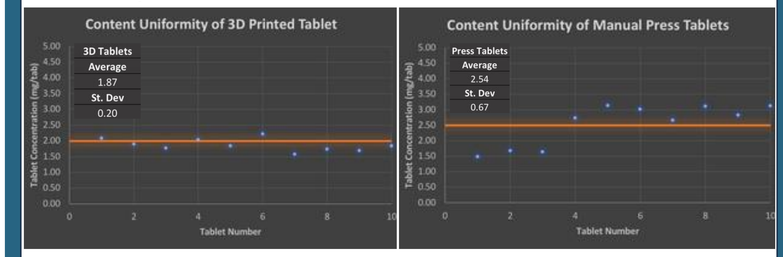

Figure 4: Content Uniformity for 3D-Printed and Compressed Tablets

Conclusions and Recommendations

Pharmaceutical tablets were successfully printed using a studied and proven bio-ink. A calibration curve was used to determine API content uniformity in 3D-Printed tablets and tablets manufactured using the traditional compression method. The content uniformity in both sets of tablets was evaluated and the tablets produced using 3D printing achieved greater uniformity (St. Dev. 0.20) than the tablets produced by compression (St. Dev. 0.67).

Future Work

Future work should be focused on evaluating the tablets hardness, disintegration, and friability to further assess their quality.

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References

Ortiz, D. A. (2023). Manufactura aditiva: La impresión 3D está cambiando a la industria. TecScience. https://tecscience.tec.mx/es/negocios-innovacion/manufactura-aditiva/