Chapter 1

Introduction

1.1 Background

In recent years, the food industry has seen numerous advancements in novel technology applications. 3D Food Printing (3DFP) has attracted interest as an emerging field with significant potential as it enables the creation of customized foods that can be tailored to specific individual nutritional requirements, offering a promising approach for future food production. For these reasons, 3DFP technology can be utilized to address prevalent nutritional issues such as iron deficiency. In addition, through precise control of the printing conditions and the deposition of the food ink, food products can be produced with complex shapes and appealing textures (Dankar et al., 2018).

A wide range of food products has been developed using 3DFP technology, including chocolates, cookies, gummies, and complete meals. The use of gummy candy as the nutrient delivery form in this research is ideal especially in children consumers, due to their appealing texture, taste, and convenience. The widespread appeal of gummy candies among children makes it valuable to create more nutritious and health-promoting versions of these products, such as the additions of essential nutrients (Tarahi et al., 2023). Spinach (*Spinacia oleracea L.*) is one of the green leafy vegetables (GLV) widely available that contains rich iron and other essential micronutrients (Naseem et al., 2023; Roberts & Moreau, 2016). There have been several developments of the use of spinach on a variety of food products to increase iron intake, such as in snack bars, biscuits, and marshmallows (Akram et al., 2023; Galla et al., 2017; Yudhistira et al., 2018). This is due to traditional iron-rich foods like spinach being often avoided by children due to their taste and texture, making appealing alternative delivery methods necessary. Based on these considerations, the development of gummy with addition of iron source using the 3DFP technology could be explored, as it might be useful to contribute in increasing iron intake.

Gummy candy uses a hydrocolloid to form a network, which retains a sugar syrup with a relatively high moisture content (Li et al., 2022). Although gelatin is typically used as the primary hydrocolloid in gummy products, other hydrocolloids have also been utilized in combination with it to improve the overall characteristics of gummy. In similar research involving iron fortified gummy, formulation using only gelatin will significantly increase hardness during storage time and create an undesirable rubbery texture (Handayani et al.,2021). Recent studies highlight the synergistic potential of hydrocolloid blends to improve textural attributes and stability (Pirsa & Hafezi, 2023). Therefore, the use of iota-carrageenan is investigated in addition to gelatin as the hydrocolloid in this formulation. Iota-carrageenan has the characteristics of creating a soft gelling texture and high elasticity, which can reduce syneresis and improve gel stability during storage (Al-Baarri et al., 2018).

In 3D food printing (3DFP) itself, gelatin-iota carrageenan undergoes a sol-gel transition. Gelatin exhibits poor thermal stability when exposed to temperatures above 35°C, meanwhile iota-carrageenan has thermal stability up until temperature 60^{o}C (Yang et al., 2020). This affects both printability of the extrusion process and self-supporting ability of the product shape stability, though these properties often contradict with each other (Zhou et al., 2023). Additionally, the 3D food printing conditions should also align with the optimized settings taken from previous research to ensure printing accuracy. Although there has been significant research done revolving around 3DFP on the printing optimization with gelatin and other types of hydrocolloids, there is still no research exploring the use of gelatin combined with iota carrageenan towards the textural properties and consumer acceptability. Based on the mentioned background above, this study will be done to investigate the effect of the gelatin-iota carrageenan mixture in the 3DFP application on the textural properties and sensory acceptability of spinach gummy.

1.2 Objective

The objectives of this study are:

1. To analyze the impact of gelatin-iota carrageenan mixture concentration towards sensory evaluation and textural properties of conventional spinach gummy.
2. To compare the textural properties and sensory acceptability of 3D printed gummy and conventional gummy.

1.3 Hypothesis

Two hypotheses were developed to predict the expected outcomes for each objective.

H_{01} : There is no significant difference in the sensory evaluation and textural properties of spinach gummy between various concentration gelatin-iota carrageenan mixture addition.

H_{a1} : There is a significant difference in the sensory evaluation and textural properties of spinach gummy between various concentration gelatin-iota carrageenan mixture addition.

H_{02} : There is no significant impact of the 3D printing process on the sensory acceptance and textural properties of spinach gummy.

H_{a2} : There is a significant impact of the 3D printing process on the sensory acceptance and textural properties of spinach gummy.