Design of Food-Inks for 3D printing of food images

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Abstract

Food Layered Manufacture (FLM) is a novel food structuring which uses the Additive Manufacturing process (commonly termed 3D printing) to shape solid or gelled foods. Material is deposited layer-by-layer by a robotics system controlled from a digital template. FLM requires greater control of structure formation than in conventional food manufacturing. This thesis examines formulation design for a prototype Food-Inks 3D printer which extrudes a fluid thread of food material (Food-Ink) to produce a 3D colour image embedded in a food item. The first Food-Ink design target is a bread-or cake-like food with an elastomeric foam structure (sponge product, SP).

Chapter 1 introduces FLM technologies, product concepts and formulation design strategies, identifies design tasks for Food-Ink formulation, and surveys current understanding of SP structure development. Chapter 2 examines flow behaviour requirements for Food-Inks on piping, colour-mixing and deposition of image voxels, and characterises the flow behaviour of model SP Food-Inks. The critical design parameters are the Food-Ink shear-thinning and viscoelastic properties, the relaxation times for stop-start-stop flow, the viscosity ratio between Food-Ink base and added colour, and the pipe diameters on pumping and voxel deposition. Chapters 4 & 5 apply a suite of test methods developed in Chapter 3 & Appendix D to examine structure development in a non-wheat SP formulation. Substitution with different flours produces variants in SP cooked structure. A blackgram bean-buttermilk soluble fraction stabilises the batter foam interface and contributes to the elastomeric protein-non-starch polysaccharide domain of the cooked SP. Flour particulates control cooked SP void organisation by modulating batter bubble size and number distributions and the liquid phase volume, while soluble flour biopolymers control bubble expansion by modulating the flow properties of the liquid phase.

The Food-Inks 3D printer applies a new technology with little supporting information in the public domain. The study concludes that SP formulations are unsuited for this application. The overall study outcomes are 1) a comprehensive identification of constraints on Food-Ink and equipment design for the Food-Inks 3D printing application, and 2) a system-level design summary for SP formulation that includes novel structuring functions identified for non-wheat flours.

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Table of Contents

Additionally, bound into this thesis is a copy of Wegrzyn, T. F., Golding, M., & Archer, R. H. (2012). Food Layered Manufacture: A new process for constructing solid foods (Trends in Food Science and Technology, 27, 66-72), which was produced as part of this study. Video files of batters prepared in the study are accessible on the CD in the pocket attached to the back cover, as are permissions for images in the text sourced from other publications.

List of Tables

List of Illustrations