Fabrication and characterization of starch-based structural materials for edible robotic applications

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Edible robots are an upcoming generation of robots, which could diversify the applications of robots in society. An edible drone could provide necessary water and food to people who have limited access to resources during emergencies. Compared to traditional drones, the mass ratio between the edible and non-edible components of an edible drone is much higher, which could potentially reduce the cost and increase the efficiency of rescuing missions.

Compared to other engineering materials, such as plastics and metals, food materials often have higher density and lower mechanical strength. Thus, fabricating structural robotic components using food materials is challenging. Previous research has proposed the usage of puffed rice cookies to fabricate edible airfoils. These airfoils were made by laser cutting the cookies into pieces and gluing them together with edible glue into a fixed shape. This way of manufacturing edible airfoils is inflexible, resourceful and inefficient. Therefore, the aim of the current work is to investigate the effects of different additives and processing methods on the mechanical properties of starch-based structural materials. Starch is chosen because it is abundant, easy to process and rich in nutrition. We hypothesized that the mechanical properties of starch-based structural materials can be modified with different processing methods and additives.

In this work, we proposed a more scalable and controllable processing method to fabricate light-weight yet strong starch-based structural components, which consists of molding and freeze drying steps. Our results showed the Young’s modulus of samples increased when edible fibers were added to the formulation, and the apparent density significantly decreased because of the pores generated by freeze-drying. We systematically investigated the influence of formulation designs using different additives (e.g. cellulose, glycerol), and were able to fabricate light-weight starch-based structural materials with a wide range of mechanical properties (i.e. from flexible to rigid). This work contributes to the development of fully biodegradable and edible robotic components with starch-based materials (e.g. for the purpose of fabricating an unpowered glider) and will bring the prospect of using food materials in other fields.