Journal of Food Engineering 216 (2018) 138–143

Contents lists available at ScienceDirect

Journal of Food Engineering

journal homepage: www.elsevier.com/locate/jfoodeng

The high precision drawing method of chocolate utilizing electrostatic ink-jet printer

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ARTICLE INFO

Article history:
Received 17 April 2017
Received in revised form
28 June 2017
Accepted 17 August 2017
Available online 18 August 2017

ABSTRACT

The objective of this study is to develop 3D food printer that can improve taste by means of creating food texture and can grant artistry which pastry chef perform by utilizing electrostatic inkjet printer high precision printing. There is a previous 3D food printer which utilizes Fused Deposition Modeling (FDM) to print chocolate. This method is to melt the material by heat and then print the material layer by layer to shape. It can only represent a rough image of the object since its print precision is rough. Furthermore, the material it can use is limited. Therefore in this study, we utilize electrostatic inkjet printing technology. By utilizing electrostatic inkjet printing, it not only enables high precision printing and grants food artistry but it also optimizes inner structure. High precision food printing is one of the important element to create food texture. We manufactured the electrostatic inkjet chocolate 3D printer and investigated its basic property. Utilized electrostatic inkjet chocolate 3D printer to print chocolate on the edible film and transfer it to a complex free surface.

1. Introduction

The objective of this study is to develop 3D food printer that can improve taste by means of creating food texture and can grant artistry which pastry chef perform by utilizing electrostatic inkjet printer high precision printing.

3D printing is a technology utilized in various fields. Stereo Lithography (SLA (Kodama, 1981; Hull et al., 1995; Lee et al., 2015; Leukers et al., 2005; Agarwala et al., 1995; Lanzetta and Sachs, 2003; Gu et al., 2012)) which can high precision print light curable resin material and inkjet printer which is utilized in medical fields such as artificial bones and joints, organs (Inzanaa et al., 2014; Murphy and Atala, 2014; Rafał and Adamski, 2015) and Selective Laser Sintering (SLS (Beuth et al., 2013; Wenbin and Miyamoto, 2006; Maeda and Childs, 2004)) which is utilized for manufacturing complex metal products and Fused Deposition Modeling (FDM (S. S. Crump inventor; Stratasys and Inc. assignee, 1992; Ahn et al., 2002; Bellini and Guceri, 2003; Sooda et al., 2010; Ahna et al., 2009; He et al., 2014; Wendel et al., 2008; Chen et al., 2016; Wei et al., 2015)) which is utilized for manufacturing architectural models or industrial product models are such examples.

We are utilizing this technology as a 3D food printer which creates food. There is a previous 3D food printer which utilizes FDM to print chocolate (Sun et al., 2015). This method is to melt the material by heat and then print the material layer by layer to shape. It can only represent a rough image of the object since its print precision is rough. Furthermore, the material it can use is limited and it needs additive to print chocolate which destroys the ideal taste condition. From these problems, study on 3D food printer is not active. Therefore in this study, we utilize electrostatic inkjet printing technology (Umezu et al., 2013; Rahman et al., 2010; Ishida et al., 2008; Choi et al., 2011; Kwon and Lee, 2013; Umezu et al., 2014; Umezu, 2014). By utilizing electrostatic inkjet printing, it not only enables high precision printing and grants food artistry but it also optimizes inner structure to create food texture. Furthermore since it can print high viscous materials, it is able to print chocolate without additive.

Hence, utilizing electrostatic inkjet printing on 3D food printing, it can able to not only improving food product appearance, but also optimize the taste of the food product. Currently, this technique is

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http://dx.doi.org/10.1016/j.jfoodeng.2017.08.017
0260-8774/

only usable by pastry. Therefore, enabling machines to be able to use this technique and making the technique generalized will make far more people to enjoy food product.

Also by utilizing edible film, it is able to transfer the chocolate to complex free surface. Decoration can be easily done by transferring high precision printed chocolate.

In this paper, we manufactured the electrostatic inkjet chocolate 3D printer and investigated its basic property. Utilized electrostatic inkjet chocolate 3D printer to print chocolate on the edible film and transfer it to a complex free surface. We will report these contents.

2. Experimental procedure

An experimental setup shown in Fig. 1 is constructed to investigate characteristics to print chocolate utilizing electrostatic inkjet.

We have made a 3D chocolate printer utilizing electrostatic inkjet printer. The schematic and the diagram of the device we have fabricated is shown in Fig. 1.

The electrostatic inkjet chocolate printer we have made applies high voltage to the liquid chocolate (HERSHEY'S, SHELL TOPPING) inside syringe and the base plate by electrode connected to high voltage power supply (voltage range kV, Matsusada Precision, GS30P), using electrostatic force to pull the material and discharge very small amount. Drawing is enabled by moving linear stage and controlling the landing surface. As controlling pressure inside syringe makes printing easier, the pressure is controlled by syringe pump (AS ONE, DR-10). The viscosity of the chocolate used in this study has been measured by viscometer (viscosity range 0.4–1000 mpa· s, SEKONIC COR., VM-10-A-L) it changes from temperature. The temperature characteristic of the viscosity measured is shown in Fig. 2. Also when temperature is under 15° C, the chocolate solidified. Using peltier element stabilizes temperature at printing environment. We have conducted the experiment at 25° C. The observation of the printed chocolate line was done by microscope.

Observation of the nozzle tip during chocolate printing was conducted by high-speed camera (Photron, FAST-CAM-MAX 120K model 1) and illumination (Sanei Electric, XEF-501S). Oblate was used as an edible film.

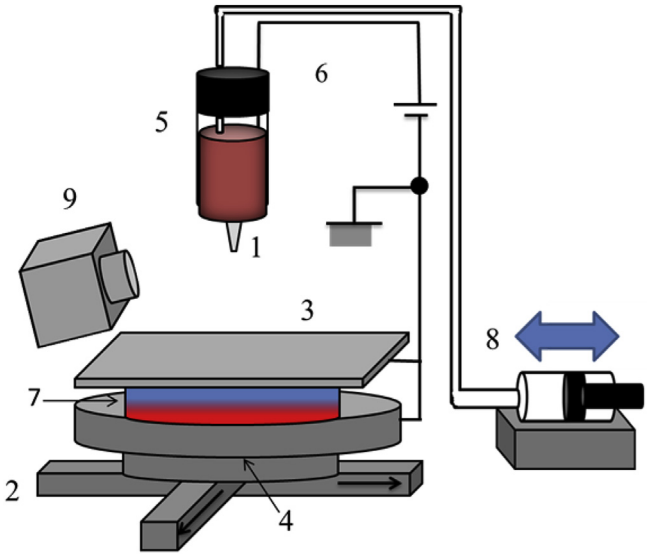

Fig. 1. Schematic of experimental setup (1:nozzle 2:x-y linear stage 3:metal plate 4:z mechanical stage 5:printing material 6:high voltage device 7:Peltier device 8:pressure device 9 microscope).

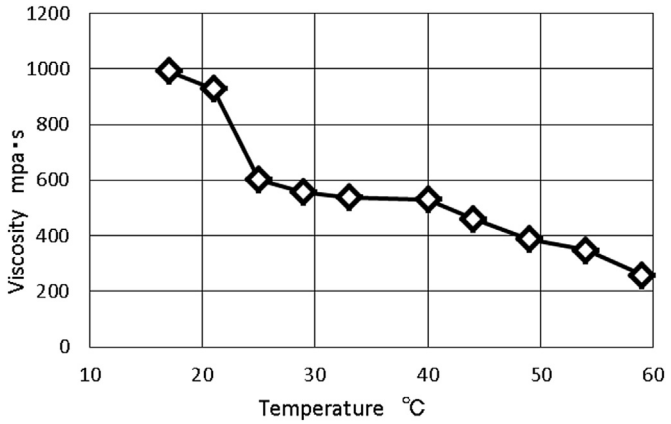

Fig. 2. The viscosity of the chocolate that is used in this experiment when temperature is changed.

3. Results and discussion

3.1. Fundamental characteristics of printing

Basic characteristic of electrostatic inkjet chocolate printer was investigated. 3 types of discharge state, drop, droplet, multi-cone, was observed from the electrostatic inkjet chocolate printer we have developed. Each situation is defined as drop; situation which droplet larger than nozzle diameter is discharged, droplet; situation which Taylor cone is formed on the tip of the nozzle and droplet smaller than nozzle diameter is discharged, multi-cone; situation which occurs when it is applied with higher voltage than droplet situation and form multiple corn on the tip of the nozzle discharging droplets in various directions. Also when the applied voltage is lower than that of drop state, discharge won't occur and when the applied voltage is higher than that of multi-corn state, electric discharge occurred. Experiment condition was set under 13[kV] to prevent electric discharge as electric discharge causes deterioration of the chocolate. The high-speed camera image and the image of the chocolate printed in the 3 types of discharge state is shown in Fig. 3.

Fig. 3(a-1),(a-2),(a-3) are captures of the high speed camera movie of drop situation printing at the tip of the nozzle. It can be observed from Fig. 3(a-1),(a-2),(a-3) that in drop situation, after the drop on the nozzle tip has gone big, gravity and electrostatic force forces the drop to fall, resulting a drop which size is larger than the nozzle diameter. Fig. 3(a-4) shows that in drop situation, chocolate will be printed in form of droplets lined up in equal interval. This state is the easiest to control of the three states, making it preferable for fabricating the outline when 3D modeling chocolate.

Fig. 3(b-1),(b-2),(b-3) are captures of the high speed camera movie of droplet situation printing at the tip of the nozzle. From Fig. 3 (b-1),(b-2),(b-3), in droplet situation, it can be observed that a triangle shape structure called Taylor cone is formed on the tip of the nozzle and discharging droplets smaller than the nozzle diameter from the tip of the Taylor cone. Also the droplets from the Taylor cone is observed dropping straight down. From Fig. 3(b-4), it is observed when printed in droplet situation, chocolates form a line whose width is smaller than nozzle diameter. This width is able to be controlled from 15 μm to 200 μm. Human taste receptor has a diameter of 50 μm. Utilizing printing precision of dozen μm, enables to manufacture a structure which can affect food taste.

Fig. 3(a-1),(a-2),(a-3) are captures of the high speed camera movie of multi-cone situation printing at the tip of the nozzle. From Fig. 3(c-1),(c-2),(c-3), in multi-cone situation, it can be observed