Fabrication of Edible lenticular lens

Takegi Yoshimoto
Meiji University
Tokyo, Japan
takegiyoshimoto@gmail.com

Nobuhito Kasahara
Meiji University
Tokyo, Japan
k.nobu00714@outlook.jp

Homei Miyashita
Meiji University
Tokyo, Japan
homei@homei.com

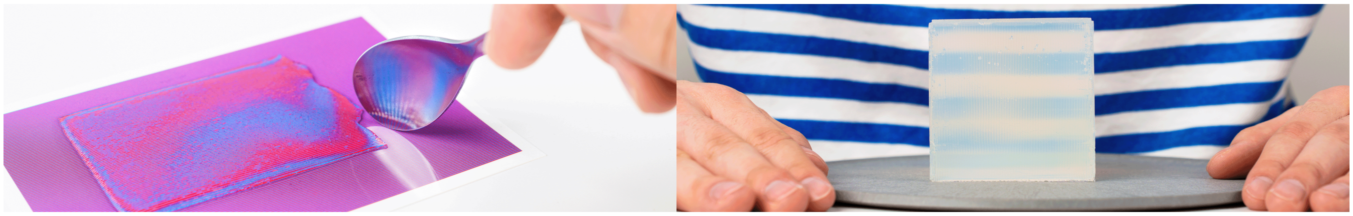

Figure 1: Fabricated edible lenticular lens. (Left) the Color changing effect, (Right) the Vanishing effect.

ABSTRACT

Lenticular lenses exhibit the color changing effect depending on the viewing angle and the vanishing effect in certain directions. In this study, we propose two fabrication methods for edible lenticular lenses. One is the mold forming method, and another is the knife cutting method using a knife with the inverse structure of a lenticular lens created by an SLA 3D printer. We also evaluate the properties of the end products. The IOR of material is optimized by using ray tracing simulation.

CCS CONCEPTS

• **Hardware** → *Emerging technologies.*

KEYWORDS

edible optics, lenticular lens, mold forming, 3D printing

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1 INTRODUCTION

Optical elements, such as lenses in HMDs (Head Mounted Displays) visual markers in projection mapping, are crucial for HCI (Human Computer Interaction). Edible optical components expand the reach of HCI technology to gastronomical experiences and medical applications [Nomura and Oku 2020; Oku et al. 2022]. We propose an edible lenticular lens with the color changing effect and the vanishing effect (Figure 1). A lenticular lens alters the images by changing the angle of vision and is composed of microscopic cylindrical lenses on a thin sheet. It allows image-switching based on viewing angles, enabling the appearance change of food materials without special equipment such as projectors or HMDs, as utilized in previously conducted research [Narumi et al. 2011; Nishizawa et al. 2016]. This allows the control of the multi-sensory interactions between vision and taste - the flavors experienced by different consumers of the same food can vary according to their viewing angles. Moreover, lenticular lenses allow optical camouflage by refracting light to make objects vanish in certain directions [Lubor 2003]. This technique can add surprise to culinary experiences, such as chocolate eggs or fortune cookies whose contents are deliberately hidden to create anticipation and reveal hidden contents. This in turn would enhance the interaction between people and food. In this study, we discuss two methods for fabricating edible lenticular lenses—one using a mold, and another using a knife created by an SLA 3D printer. Furthermore, the performance of the lenses manufactured by each method is analyzed.

2 METHODS

Edible lenticular lenses comprise gellan gum, a natural polysaccharide from Sphingomonas elodea. While agar was previously used for its high transmittance and shape reproducibility [Nomura and Oku 2020], gellan gum has better transmission at the same concentration, making it ideal for edible optics. Moreover, we used Suntory's Yogurina as a solution, which is tasty and contains sugars that can increase the IOR (index of refractive).

2.1 Mold Forming Method

This subsection describes the fabrication process of edible lenticular lenses using a mold forming method. For color changing effect, a silicon mold is made using a conventional lenticular lens with 40 LPI (lines per inch), and the radius of each cylindrical lens is 0.68 mm. The silicon resin used in creating a negative mold is food-grade (HTV-2000, Engraving Japan). A mixture of 250 g of yogurina and 5 g of gellan gum powder is poured into the mold after mixing and boiling. Small bubbles are removed with a thin instrument. The solution is left at around 20 °C for 30 mins to complete the manufacturing process. For the vanishing effect, a cube of length 65

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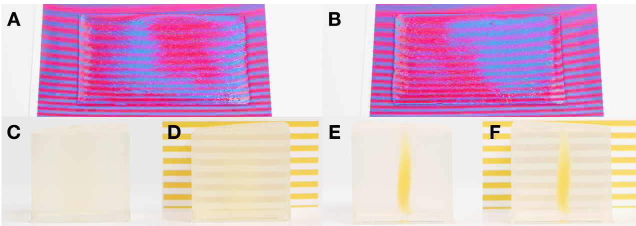

Figure 2: (A-B) Fabricated edible lenticular lens. A and B show the color changing effect, (C-F) Fabricated edible optical camouflage. C and D represent the anterior view of the jelly, and the contents are not visible. E and F represent the posterior view of the jelly, with the yellow peaches being visible.

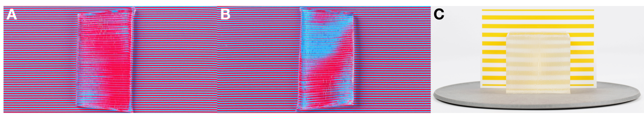

Figure 3: Edible lenticular lenses fabricated using the knife cutting method. (A-B) The images are of the lens rotated 180°, (C) Image depicts the verification of the vanishing effect.

mm is made with an FDM 3D printer to form the basis of a silicon mold. All faces, except the bottom face, are connected using the aforementioned lenticular lenses. A negative mold is created with the food-grade silicon resin, and a mixture of 3 g of gellan gum powder and 450 g of yogurina is poured into the silicon mold after mixing and boiling. Small bubbles are similarly removed from the surface. The mixture is left at around 20 °C for 2 hours to complete the manufacturing process.

2.2 Knife Cutting Method

This subsection outlines the process of creating a lenticular lens structure by slicing a regular jelly cube using a 3D-printed knife with an inverse lenticular lens structure. Compared to mold forming method, this procedure is faster and more efficient as it does not require a mold. The SLA 3D printer (SATURN 2, ELEGOO) was used to fabricate the prototype knife. We utilize the allergy-free washable resin (ekimate clear color, NSS Inc.), a food-safe material. First, a 3D model of the knife, comprising an inverse lenticular lens structure with 20 LPI (the radius of each cylindrical lens is 0.77 mm), was created in Fusion 360 and printed using SATURN 2. Subsequently, a jelly cube with edges measuring 65 mm and an equal concentration compared to that described in Section 2.1 is fabricated. Finally, it is cut with the knife, allowing us to create the structure of a lenticular lens on the sliced surface.

3 PERFORMANCE EVALUATION

3.1 Color Changing Effect

The IOR of gellan gum solution is measured using a refractometer (HI96801, HANNA). The solution utilized during prototype creation is used at a measurement temperature of 21.4 °C. The measured IOR is 1.3433. The color changing effect is confirmed by observing the images from different viewing angles. The fabricated lens is placed on a 40 LPI lenticular image, which is combined with a red monochromatic image and a blue monochromatic image and printed on a 3R glossy photo paper (Crispia Photo Paper, Epson) using the printer (EW-5071FT, Epson). A and B in Figure 2, 3 depicts two photographs of the prototype rotated through 180°. Conventional lenticular lenses change from red to blue, but the prototype exhibits a pattern in which the two images are mixed. This can be attributed to the softness of the gellan gum. It is deformed when removed from the mold or by external forces, thereby shifting the pitch of the image. However, this problem can be resolved by adjusting the gellan gum-to-solution ratio.

Figure 4: Comparison of vanishing effects between real and ray-tracing simulation.

3.2 Jelly Cube with Vanishing Effect

The available properties for the vanishing effect are LPI, object to lens distance and IOR. It was not easy to change the distance and LPI. Smaller IOR leads to more clear jelly and smaller vanishing effect, while higher IOR leads to less clear jelly and larger effect. We need to find the smallest IOR that leads enough effect. We investigated ray tracing simulation and made jellies with different IORs (Figure 4). Then the optimized IOR was 1.3448.

The vanishing effect was confirmed by placing a yellow peach cut lengthwise (4 cm long, 1 cm wide) on one side of the jelly cube. To demonstrate the transparency of the jelly and the visibility of the background, a yellow stripe pattern is printed on aforementioned photo paper and placed behind the jelly cube. Figure 2 (C-F), 3 (C) depict anterior and posterior images of the jelly cube with and without stripes. The yellow peaches in the jelly cube seems disappear, but the stripes beyond the posterior surface are visible.

4 FUTURE WORK

The knife cutting method is a viable method for fabricating, although it is less precise than the mold forming method owing to the hand-cutting process. In future work, we are planning to create an Edible lenticular lens design system that allows for variable lens thickness and pitch cutting from jelly cubes, to improve the accessibility.

REFERENCES

Fiedler Lubor. 2003. Magic trick with vanishing effect. US20030054894A1.

Takuji Narumi, Shinya Nishizaka, Takashi Kajinami, Tomohiro Tanikawa, and Michitaka Hirose. 2011. Meta Cookie+: An Illusion-Based Gustatory Display. In *Virtual and Mixed Reality - New Trends*, Randall Shumaker (Ed.). Springer Berlin Heidelberg, Berlin, Heidelberg, 260–269. https://doi.org/10.1007/978-3-642-22021-0_29

Masahiro Nishizawa, Wanting Jiang, and Katsunori Okajima. 2016. Projective-AR System for Customizing the Appearance and Taste of Food. In *Proceedings of the 2016 Workshop on Multimodal Virtual and Augmented Reality* (Tokyo, Japan) *(MVAR '16)*. Association for Computing Machinery, New York, NY, USA, Article 6, 6 pages. https://doi.org/10.1145/3001959.3001966

Miyu Nomura and Hiromasa Oku. 2020. Edible lens made of agar. *Optical Review* 27, 1 (01 Feb 2020), 9–13. https://doi.org/10.1007/s10043-019-00557-9

Hiromasa Oku, Miko Sato, and Yuki Funato. 2022. Edible Retroreflector Made of Candy. *IEEE Access* 10 (2022), 24749–24758. https://doi.org/10.1109/ACCESS.2022.3155603