

Unlimited Electric Gum: A Piezo-based Electric Taste Apparatus Activated by Chewing

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Figure 1. (a) Electric taste apparatus: Unlimited Electric Gum. (b) Image of a user chewing the apparatus. (c) Waveform of the piezoelectric voltage.

ABSTRACT

Herein, we propose “unlimited electric gum,” an electric taste device that will enable users to perceive taste for as long the user is chewing the gum. We developed an in-mouth type novel electric taste-imparting apparatus using a piezoelectric element so that the piezoelectric effect is stimulated by chewing. This enabled the design of a device that does not require cables around a user's lips or batteries in their mouth. In this paper, we introduce this device and report our experimental and exhibition results.

Author Keywords

Electric taste; chewing activities; virtual reality.

INTRODUCTION

Electric taste, which is induced by galvanic taste simulation (GTS), is being utilized as one of the control methods of taste sensation in the area of Human-computer interaction.

Aoyama et al verified the inhibitory effect of GTS on all five basic tastes induced by electrolyte materials [1]. Nakamura et al defined as the sensation that is evoked when gustatory organs or nerves are electrically stimulated.

Furthermore, they presented the method of applying electrical current to food and drinks [4] to regulate saltiness without adding salt [5]. Ranasinghe et al. developed the device that changes a cocktail taste and flavor with electric

taste, visual effects, and smell [6]. Many studies on electric taste have been conducted in recent years.

Since conventional methods used in previous studies require external power supply, these are inconvenient for everyday use. For example, one would hesitate to use an eye-catching device and have cables around their mouth when eating at a restaurant. A rational solution would be to attach a small battery and stimulation circuit inside the mouth of a user. However, this will give rise to another problem: harmful chemicals may leak from the battery into the mouth of the user.

Considering humans eating situation, they chew food to soften and reduce the size of the food particles. Therefore, we invented the electrical stimulation system which generate the electric power by chewing it. We used a wrapped piezoelectric element, which produces electricity on being chewed. Through the use of piezoelectric elements, an electric taste apparatus, which does not require power supply, can be designed. Thus, we invented a novel device named “Unlimited Electric Gum.”

In this paper, we describe the electrical characteristics of the device and effect on the taste sensation.

SYSTEM

Piezoelectric Element

A piezoelectric element is an electronic component that generates electricity through the piezoelectric effect. Piezoelectricity is the phenomenon that electric charges are generated when stress is applied to solid materials.

The piezoelectric element used in this study is 15 mm in diameter (crystallization diameter is 12 mm). It was covered with a plastic or polyimide film to prevent short-circuiting due to saliva and/or oral contact.

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We developed two devices. One was using only one piezoelectric element and other was two elements connected in parallel. It is rational to be considered that the device using two piezoelectric elements can generate stronger stimulation. To make application of pressure to the element easier when chewing, we attached a saucer-shaped cover made of acrylic.

Electrode

When the piezoelectric element is wrapped with the film, we inserted two silver boards (width: 3 mm, thickness: 0.1 mm) to serve as the electrode. Silver electrodes were used as silver is chemically stable.

MEASUREMENT

Human can perceive electric taste when the current is higher than 4 μA [2]. We measured the voltage and ampere which our apparatus can output using 800 Ω resistance (internal tissue resistance: 500 Ω , resistance of wet skin: 300 Ω) [3], as a model of the human body.)

A pressure sensor was sandwiched between the apparatus to measure chewing power. Chewing position was determined to be the first or second top and bottom molar teeth as Fig. 1(b). Six participants (age: 23-24) enrolled in this experiment. Three participants (s1-3) chewed on single-piezoelectric type device, and the other three participants (d1-3) chewed on double-piezoelectric type device.

We instructed them to chew our device as they chew gum. Each participant completed 20 times. We set five chews as one set of measurement, and we instructed participant that they chew right side and left side every 2 sets.

Fig. 1(c) shows one of the waveforms obtained during the chewing experiment. The voltage and reverse voltage were similar size in each chewing trials. The data used to plot electric current which was calculated using measured voltage and human body model was strong enough to induce electric taste. The amperage tended to increase with increase in chewing power. Further, providing amperage was easier in the case where two piezoelectric elements were used than in that where only one element was used.

Consideration

The minimum electric current required for imparting electric taste is 4 μA , and the peak of the weakest amperage in this experiment was 2 mA. This implies that piezoelectric elements can be used to impart electric taste. Although current is generated for short time per stimulation, its strength is higher than the threshold for inducing electric taste. If taste is not felt, the duration of current generation per stimulation should be extended. Providing amperage became easier with increase in chewing power and number of piezoelectric element. We believe that the intensity of taste can be controlled by adjusting the amperage. In this paper we modeled the current path of inner mouth for directly connect with the resistance of wet skin and internal tissue. However, in deed, there should be shortcut consist of saliva. Therefore, the net current strength flows into the human body would be less than the result of this paper.

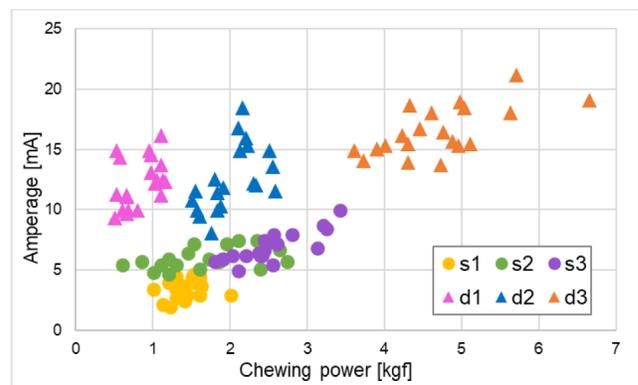


Figure 2. Amperage vs. chewing power (s1-3: one piezoelectric element, d1-3: two piezoelectric elements).

TASTING

When we applied pressure to the apparatus by chewing, or release the pressure, we were able to perceive bitterness and saltiness. The taste felt with the two-element device was stronger than with the one-element device even when the chewing power was the similar. However, the intensity of taste did not change with change in chewing power. Chewing the device did not cause pain.

Feedback from Exhibits

At Japanese domestic conference named Interaction2018 (which took place in Tokyo from March 5 to March 7, 2018), we exhibited this device and approximately 80 participants consented to try it. Almost all of them could sense a taste, which was reported to be salty or bitter by most participants. Some participants reported that the taste was more like that of “Niboshi” than that of a gum.

CONCLUSION

To solve the problems associated with wiring and battery positioning for power supply in electric taste devices, we developed a novel method using piezoelectric elements. This study demonstrates that our device generates a high enough electric current and participant felt bitter and salty sensations on chewing our device. The results obtained indicate that this method can be applied to electrical taste devices.

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