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# The Regularity in the Number of Kompeito Protrusions

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**Abstract**

We researched the regularity of the protrusions of Kompeito. We found that, by counting manually, the number of protrusions appears in multiples of three. Also, we simulated how it turns into Kompeito. We assume this phenomenon is due to the pieces hitting against each other.

## １. Motive for research and background

Kompeito is a kind of Japanese candy made from sugar. A physicist, Terada Torahiko, researched the cause of making Kompeito protrusions in the Meiji Period. However, that is still not completely understood. So, we decided to uncover the secret hidden in the shape of Kompeito.

## ２. Method・Result

**Experiment 1**

We manually counted the number of protrusions of 335 Kompeito sold in store because we wanted to determine how many protrusions the average Kompeito had.

We checked the number of Kompeito protrusions using a pen. We defined protrusions as being higher than they were wide. For instance, we thought of the left hand picture as two protrusions. We regarded middle and right hand picture as one protrusion.

**Result 1**

We created graph1. The horizontal axis indicates the number of Kompeito protrusions and the vertical axis indicates the number of Kompeito with that number of protrusions. Looking at graph1, you can see we found a lot of Kompeito had 21, 24 and 27 protrusions. Graph1 is shaped like a mountain.

**Discussion 1**

From the result, three protrusions are made per one top point because of the sugar water sticking to the core. We considered that each protrusion grows up so that the number of protrusions appears the multiple of three.

Then, to verify the ratio of “the data” to “right and left data”, we defined the increasing rate “α”.

$$\alpha = (\text{data}) \div (\text{average of right and left data})$$

Graph 2 shows α. Kompeito that have 27, 30 or 33 protrusions are high value of α. That means the number of Kompeito has 27, 30 or 33 protrusions are sharp increasing. However, the data about the start and end value have a low level of accuracy, because the

number of that value is small. Accordingly, we need to compare Graph2 with another normal distribution such as Poisson distribution.

**Experiment 2**

To prove the regularity we found in Experiment1, we tried to make Kompeito by ourselves. We made a device made of a cylinder can, stands, and a metal stick.

First, we heated it to 60 degrees, and put cores (poppy seeds) into it. Second, we poured water containing a 40% concentration of sugar and rolled it once a minute. We continued this method for an hour.

**Result 2**

We performed this experiment three times. However, the cores didn't turn into Kompeito. They mixed with the sugar water and became a mass.

**Discussion 2**

There are two reasons why we couldn't succeed in making Kompeito.

First, there isn't enough time. It takes a week to complete Kompeito, however, we took only three hours. Second, the device was too small. The diameter was reduced to one-tenth so that the collisions didn't happen very much.

**Experiment 3**

We used a frying pan to make Kompeito. We put 100 poppy seeds into frying pan and poured in 5mL of 40% sugar water. We repeated process by taking the frying pan away from the heat when it got hot, and putting it back when it got cold.

**Result 3**

We repeated this 30 times. While doing it, something like Kompeito formed. They were things that some poppy seeds gathered by sugar water.

**Discussion 3**

In this experiment, we could not get the outcome where cores grew individually, but we could get another outcome where something like Kompeito was made by gathering cores. This is the result that each core did not collide.

**Experiment 4**

It takes much time to make Kompeito. So, we wanted to simulate how the particles stick to the core. We decided to use a super ball as a core instead of poppy seeds and a small sponge, and paste as sugar water. We smeared the paste on the super ball and put the super ball and 5mm sponge pieces in the bowl. Afterwards, we rocked the bowl, and the sponge stuck to the super ball. After the sponge dried, we repeated this process three times.

**Result 4**

Sponge was so rough that we could not see deviation of sponge that stuck to the super ball.

**Discussion 4**

Its external form became a sphere. This was because of the shape of super ball. We used a super ball which had uneven surface. But the difference in height was only

1mm, so the uneven face did not influence how the sponge stuck to the super ball.

## 3. Conclusion

From these experiments, we found that the number of protrusions appears in multiples of three the most, which is influenced by the shape of the cores.

The process of sugar water sticking to the rough surface of the core determines the number.

This time, we tried to prove the regularity we found by performing several experiments. The regularity was one from commercial Kompeito, so we wanted to know if we could get the same regularity on the Kompeito we made. However, it was difficult. There were two factors: the time of the experiments and the management of the temperature was not enough.

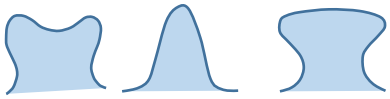
## 4. References

金平糖とその類似構造 中田友一 中京大学国際教養学部（2011）『形の科学会誌』
ヴォイニッチの科学書 中西貴之 http://obio.net/science/262.htm

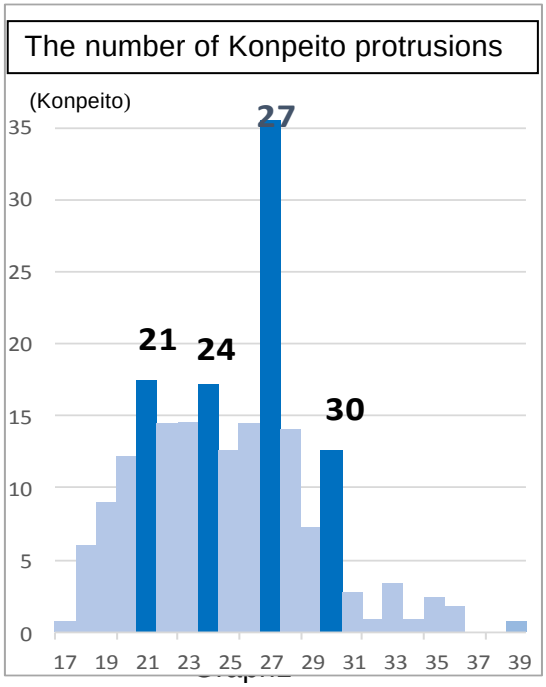
## 5. Key words

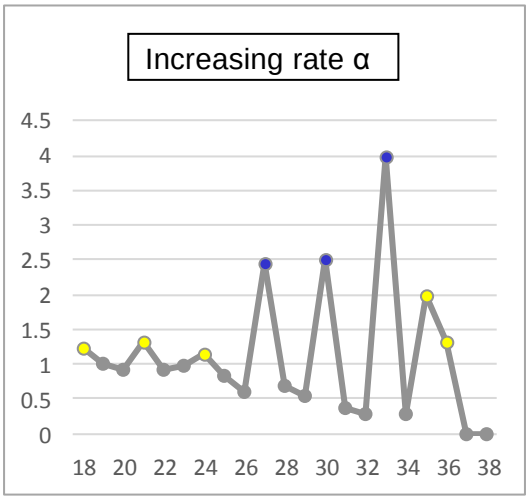
Kompeito protrusion

## 6. Figure・Graph



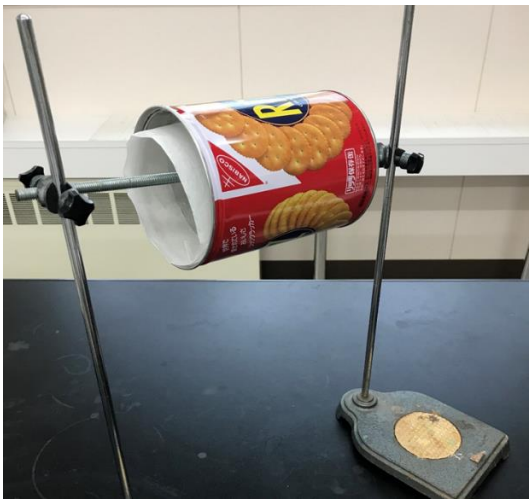
Picture



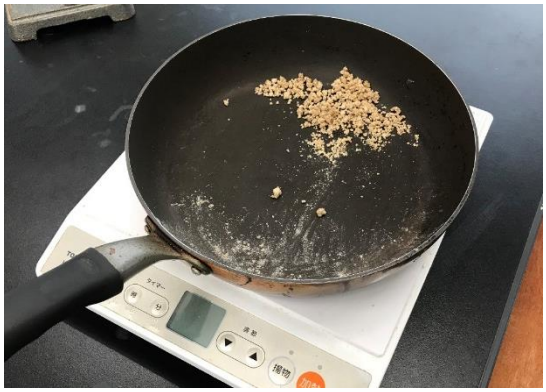




Graph2

(Konpeito protrusions)



Device (Experiment2)



Device (Experiment3)

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