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DSC-60 Plus Differential Scanning Calorimeter

Application News

Measurement of Glass Transition of Food Products by Differential Scanning Calorimeter

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User Benefits

- Measurement of the glass transition with the DSC-60 Plus makes it possible to estimate the hardness of food products from their glass transition temperature.
- By using the DSC-60 Plus, it is possible to investigate the relationship between the moisture content and glass transition temperature of foods.

■ Introduction

The hardness of food products is an important item in product development and quality control from the viewpoints of food texture ("mouthfeel") and processability. Although various factors cause differences in the hardness of food products, including the crystal structure, moisture content, and density of the food, the glass transition also has a large influence. As in the case of polymeric materials, many foods become soft and rubbery at temperatures higher than the glass transition temperature, and become hard and brittle and glass-like at lower temperatures. The glass transition temperature of foods changes depending on the moisture content and the glass transition temperature of their component substances. Here, the glass transition temperatures of a soft candy and hard candy with different mouthfeels, three types of saccharides (sugars), and a soft candy with different moisture contents obtained by heat treatment were measured using a Shimadzu differential scanning calorimeter (DSC-60 Plus). The results are introduced in this article.

■ Measurement of Candies with Different Mouthfeels

A commercially-available soft candy and hard candy were measured with the DSC-60 Plus, and the differences in their glass transition temperatures were compared. Table 1 shows the measurement conditions, Fig. 1 shows the appearance of the DSC-60 Plus, and Figs. 2 and 3 show the measurement results.

Table 1 Measurement Conditions

Instrument	: DSC-60 Plus TAC-60i Electric Auto-cooling Attachment
Cell	: Aluminum seal cell
Heating and cooling rate	: 10 ˚C/min
Temperature conditions	: -40 ˚C→ 140 ˚C
Atmosphere	: Nitrogen, 50 ml/min

Fig. 1 DSC-60 Plus

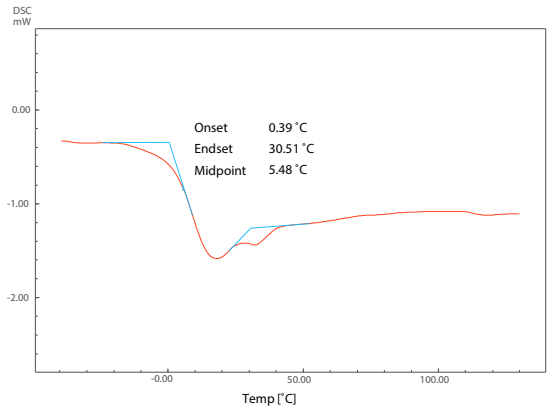

Fig. 2 Measurement Results of Soft Candy

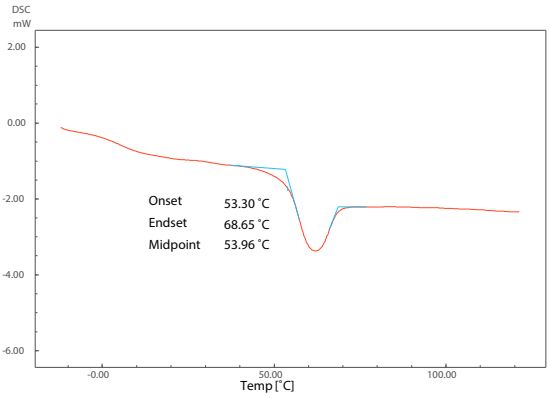

Fig. 3 Measurement Results of Hard Candy

From Fig. 2 and Fig. 3, a comparison of the glass transition temperatures shows that the onset temperature of the soft candy is 0.39 ˚C, which means the candy is in a rubbery state at room temperature. In contrast, the onset temperature of the hard candy is 53.30 ˚C, indicating that the candy is in a glassy state at room temperature. As for the mouthfeel of the two candies, at room temperature, the soft candy is soft, while the hard candy is hard and brittle, which is consistent with the hardness relationship expected from the difference in the glass transition onset temperatures of the respective candies.

■ Measurement of Saccharides

The glass transition temperature of foods generally changes depending on the glass transition temperatures of the components they contain[1]. Here, the glass transitions of fructose, glucose, and sucrose were measured as examples of the saccharides (sugars) contained in food products. Table 2 and Fig. 4 show the measurement conditions and measurement results, respectively. Because a clear glass transition could not be observed during the first temperature heating, only the results for the second temperature heating are shown here.

Table 2 Measurement Conditions

Instrument	: DSC-60 Plus TAC-60i Electric Auto-cooling Attachment
Cell	: Aluminum seal cell
Heating rate	: 10 ˚C/min
Temperature drop rate	: 99.9 ˚C/min
Temperature conditions	: Fructose Room temperature → 140 ˚C → -20 ˚C → 80 ˚C Glucose Room temperature → 190 ˚C → -20 ˚C → 100 ˚C Sucrose Room temperature → 200 ˚C → -20 ˚C → 140 ˚C
Atmosphere	: Nitrogen, 50 ml/min

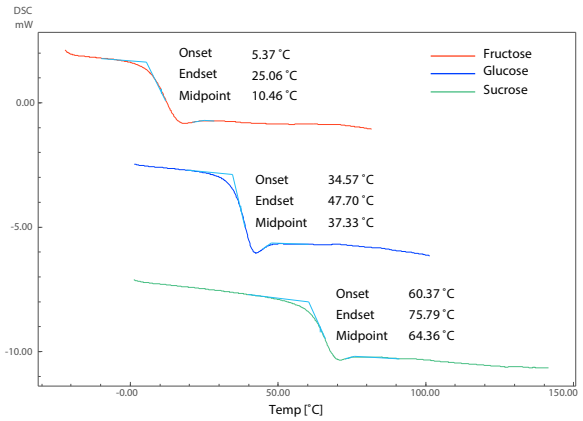

Fig. 4 Measurement Results of Fructose, Glucose, and Sucrose

From Fig. 4, it can be understood that the glass transition temperatures of the respective saccharides are different. Based on these results, for example, the glass transition temperature of a food using fructose, which has the lowest glass transition temperature, will be lower than the glass transition temperatures of foods using the other two types of sugars, and that food can be expected to be soft at room temperature.

■ Measurement of Heat-Treated Soft Candy

The glass transition temperature of foods generally changes depending on the moisture content. Here, heat treatment was applied to a commercially-available soft candy, and the glass transitions of the samples after vaporization of the water were measured and compared. Table 3 shows the heat treatment conditions and the moisture content of the samples after heat treatment, Table 4 shows the measurement conditions, and Fig. 5 shows the measurement results. The moisture contents of the samples after heat treatment were calculated from the weight loss up to 120 ˚C, which was obtained by thermogravimetry.

Table 3 Heat Treatment Conditions and Moisture Contents of Samples After Heat Treatment

Heat treatment condition	Moisture content of sample
No heat treatment	1.6 %
110 ˚C × holding for 5 min	0.8 %
110 ˚C × holding for 30 min	0.7 %

Table 4 Measurement Conditions

Instrument	: DSC-60 Plus TAC-60i Electric Auto-cooling Attachment
Cell	: Aluminum seal cell
Temperature drop rate	: 10 ˚C/min
Temperature conditions	: -40 ˚C → 140 ˚C
Atmosphere	: Nitrogen, 50 ml/min

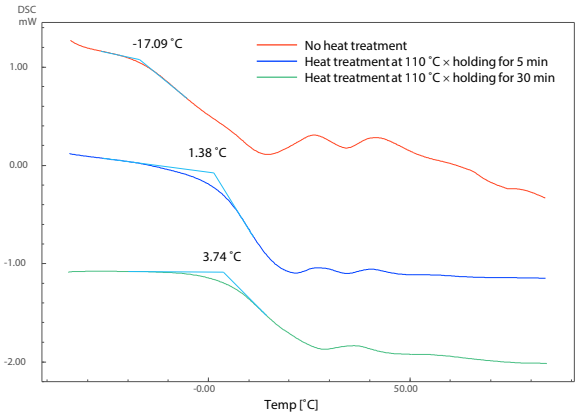

Fig. 5 Measurement Results of Soft Candy with Different Heat Treatment Conditions

Fig. 5 indicates that the glass transition temperature shifts to the high temperature side as the heat treatment time is extended. Based on this, it is expected that the glass transition temperature will shift to the high temperature side due to a decrease in the moisture content in the food, and as a result, the candy will become hard and brittle.

■ Conclusion

In this article, the glass transitions of a soft candy and hard candy with different mouthfeels, three types of saccharides, and a soft candy with different moisture contents obtained by heat treatment were measured by DSC. As a result, it was found that the glass transition temperature of the soft candy was lower than that of the hard candy, which was consistent with the difference in the mouthfeels of the two candies. In addition, the glass transitions of the different types of saccharides and the candy with different moisture contents were also measured, and the differences in their respective glass transition temperatures could be confirmed. Based on these facts, it was suggested that the hardness of food products can be estimated by comparing the glass transition temperatures obtained by DSC.

<References>

1) K. Kawai, "Glass Transition Properties and Quality Control of Food," Japan journal of food engineering, Vol. 19, No. 1, pp. 9-14, March. 2018

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