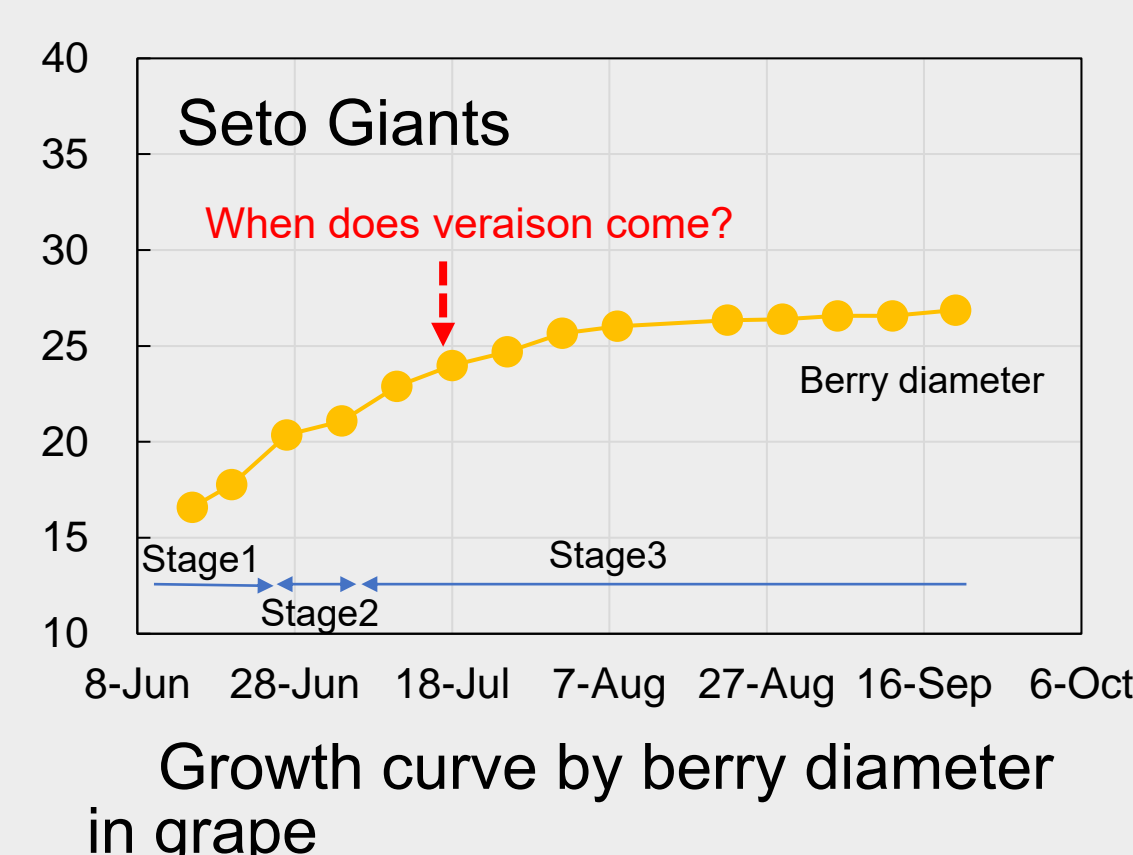


# Nondestructive evaluation of berry softening by an acoustic vibration method in three grape cultivars

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## Introduction

Grape berry shows double sigmoidal growth during its development. It is divided into three stages, Stage 1, rapid growth, Stage 2, the lag stopping its enlargement, and Stage 3, including regrowth time and subsequent maturation period. At beginning of Stage 3, the time which berries soften rapidly is coming. it is called “veraison” and its timing is not clear, especially in white grape cultivars, because their berries continue to be greenish visually after that.



Acoustic vibration method had already used to presume internal condition such as flesh firmness in various fruit.

Recent year, a mobile instrument with one point touching sensor was developed, and this method came to be used to on-tree fruit easily.

Thus, we examined to trace the change of flesh firmness in each berry by an acoustic vibration method using this instrument.

## Materials and Methods

**Plant materials:** Three white grape cultivars grown in a same plastic film house of Field Science Center affiliated to Faculty of agriculture, Okayama University were utilized in 2022.



Shine Muscat (SM) Seto Giants (SG) Muscat of Alexandria (MA)

Three grape cultivars in this research

- ◆ Different flesh texture in mature berry; MA: very soft, SM: juicy hard, SG: crispy hard
- ◆ MA is seeded and SM and SG are seedless artificially
- ◆ Harvest time in SM is later than other two cultivars

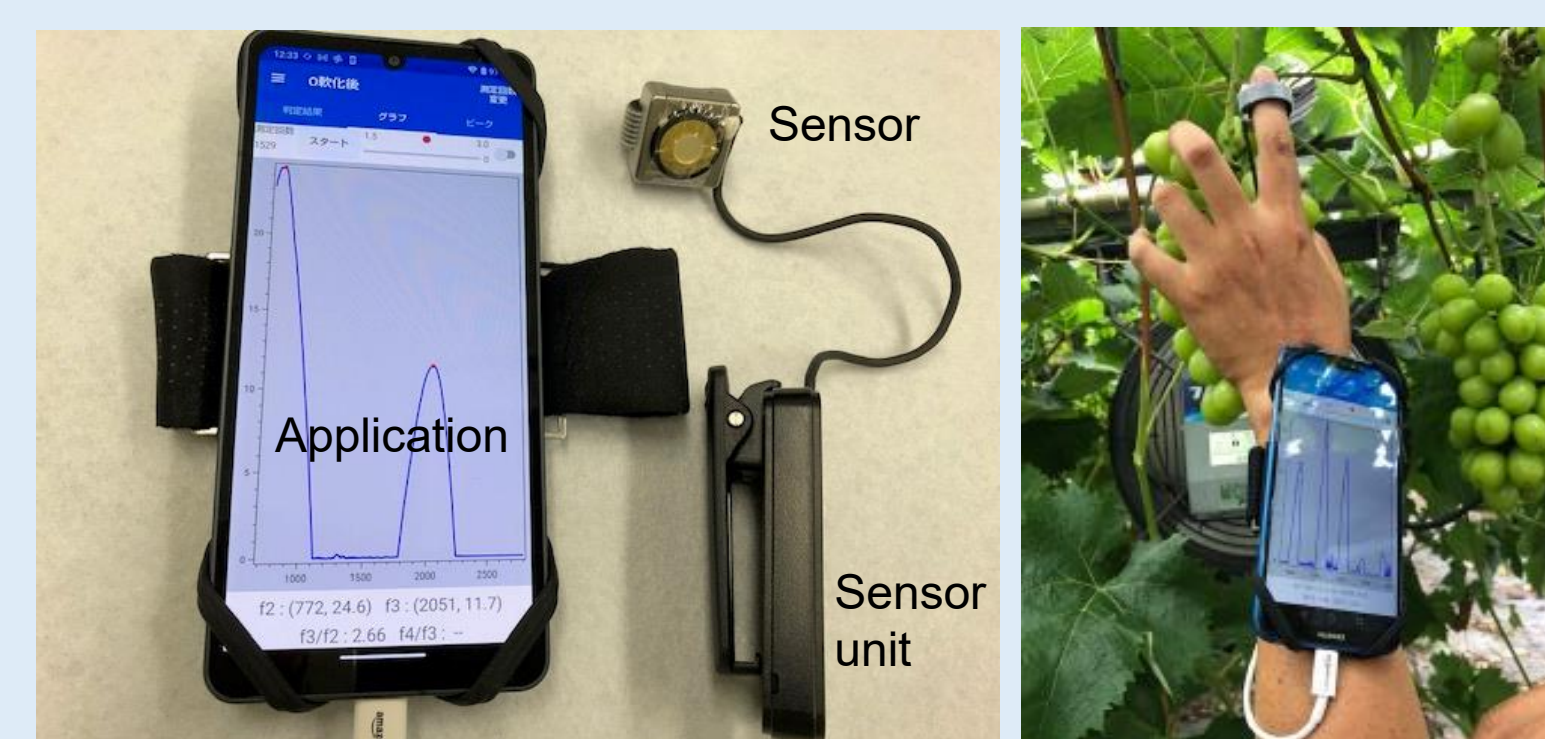
### Continud investigation of berry size and resonant frequencies:

Four berries from five bunches were selected on mid of June, and length, diameter and resonant frequencies of them were investigated from end of June to mid of September. Resonant frequencies were measured using a mobile acoustic vibration instrument (YUBIKEN, Applied Vibro-Acoustics. Inc., Japan). Acoustic vibration was given in a range of 500 - 4000Hz as scanned for three seconds. Also, elasticity Index (EI) was calculated from berry diameter and third resonant frequency (f3) based on the following formula:

$$EI = (\text{diameter})^2 \times (f3)^2$$

### Investigation of flesh firmness and sugar and acid contents:

Five berries from other bunches were collect to some timing. Flesh firmness were investigated by a rheometer with 3mmΦ cylinder plunger. Sugar and acid contents in each collected berry were measured using Sugar acid meter (Atago, PAL-BXIACID2) since August.



Sensor unit (right) and smart phone installed an application analyzing some peaks of the resonant frequency

Measurement on tree  
The sensor is touched to berry apex kindly.

A mobile acoustic vibration instrument (YUBIKEN, Applied Vibro-Acoustics. Inc., Japan)

- ◆ One Scan is finished for three second, and the peak diagram and values of resonant frequencies are indicated on the monitor of smart phone immediately.
- ◆ Acoustic vibration was given to a berry at the range of 1000-4000 or 500-2500 before or after veraison, respectively.
- ◆ We could measure resonant frequencies in each berry, even if the berries are closely attached within a bunch.

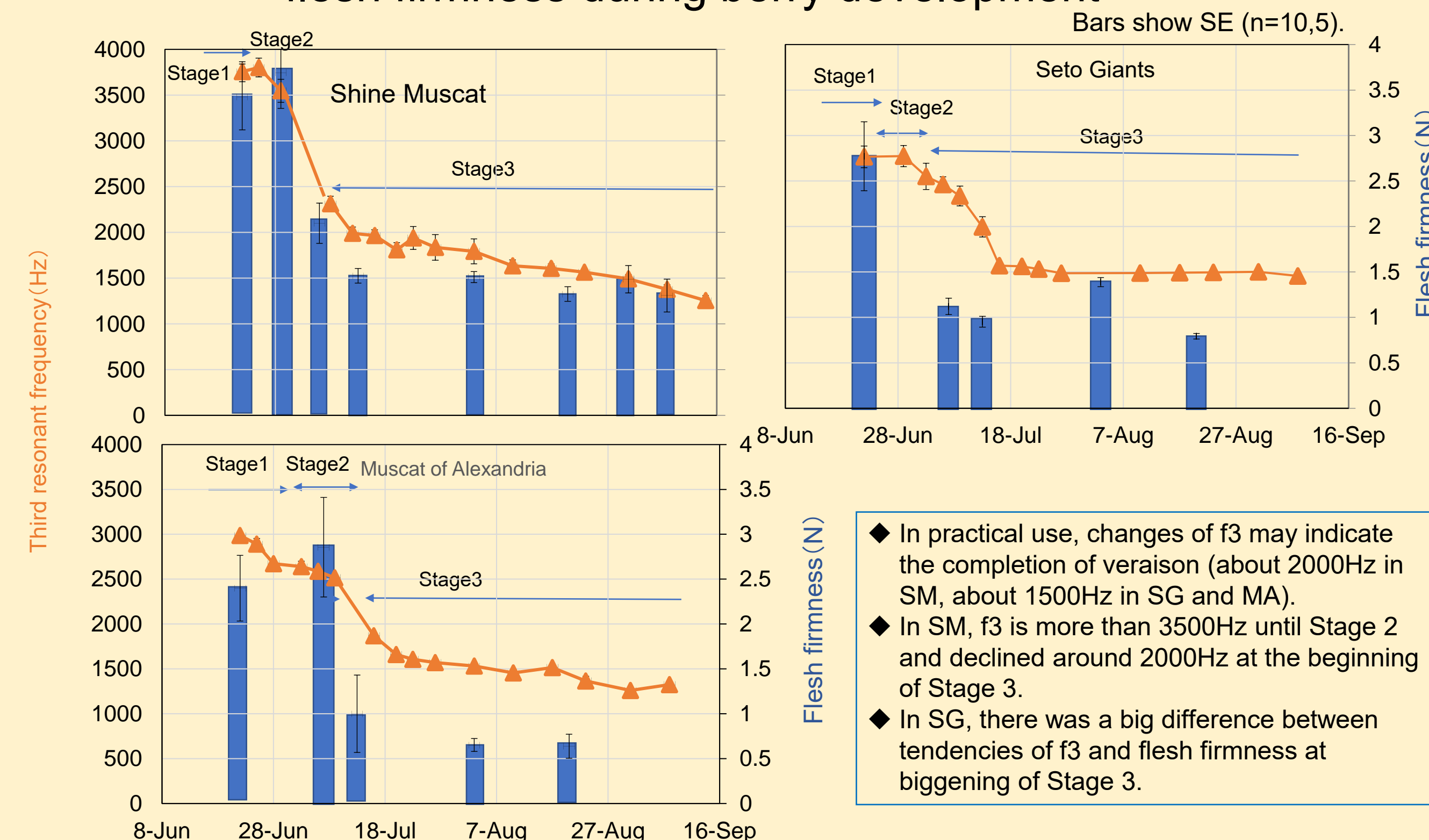
## Results and discussion

### Continuous investigation of resonant frequencies of berries in three cultivars

In each berry, f3 could be easily measured from the end of Stage 1 of fruit development to the harvest time of each cultivar. In all three cultivars, f3 were highest until the beginning of Stage 3 of fruit development (2800-3800Hz). After that, f3 decreased rapidly in MA, but f3 decreased more slowly in SM and SG than in MA. In all cultivars f3 decreased to 1500-2000 Hz until 18th July. Since August, f3 continued to decrease gradually beyond the harvest time in SM and MA, but f3 were constant until early September in SG. When changes in flesh firmness by a rheometer using berries collected from other bunches were compared with the changes in f3, their trends were almost matched.

Changes in EI, which is calculated from berry length and f3, were matched more closely to that of flesh firmness and it was recognized the timing indicating the lowest EI as the completion of berry softening (veraison) in each cultivar.

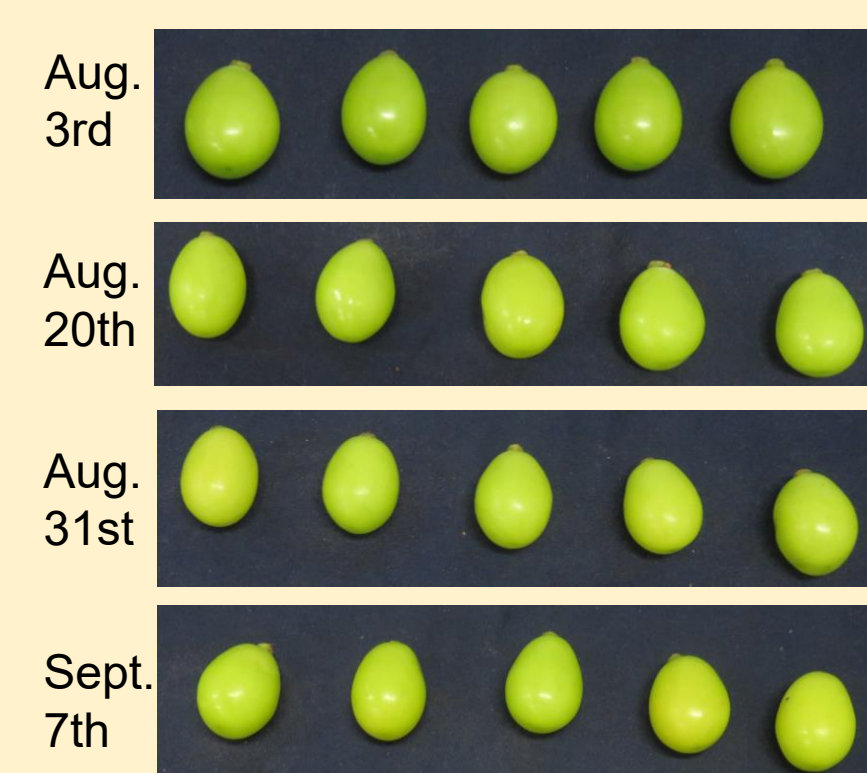
### Comparison between tendencies of third resonant frequency and flesh firmness during berry development



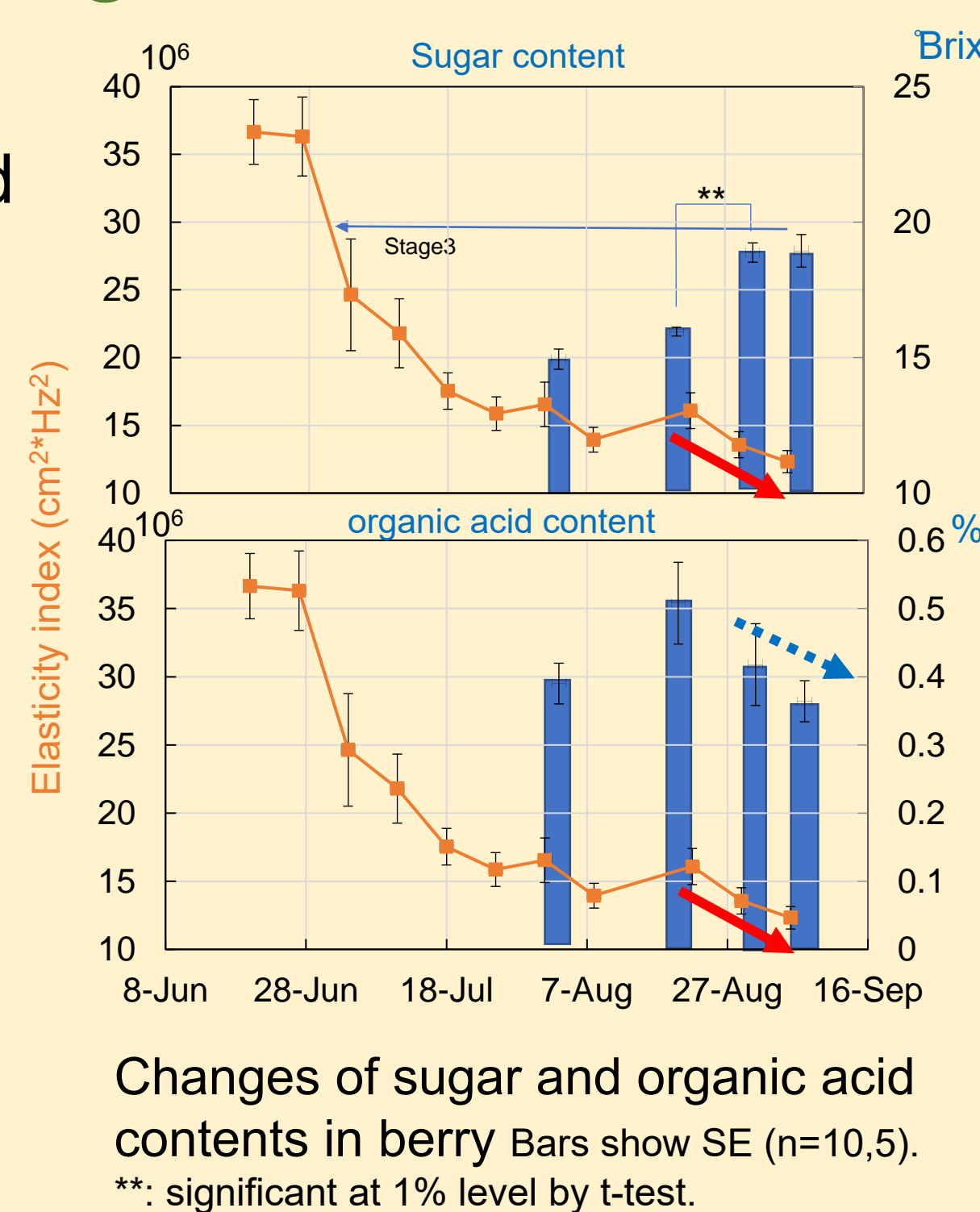
### Change of EI toward mature stage in SM

There was no difference in appearance of sampled berries since 20 August, but EI of berries in continued investigation was obviously decreasing since 22 August in SM. On the other hand, sugar content was significantly increased and reached more than 18° Brix. Inorganic acid content began to decrease at that time.

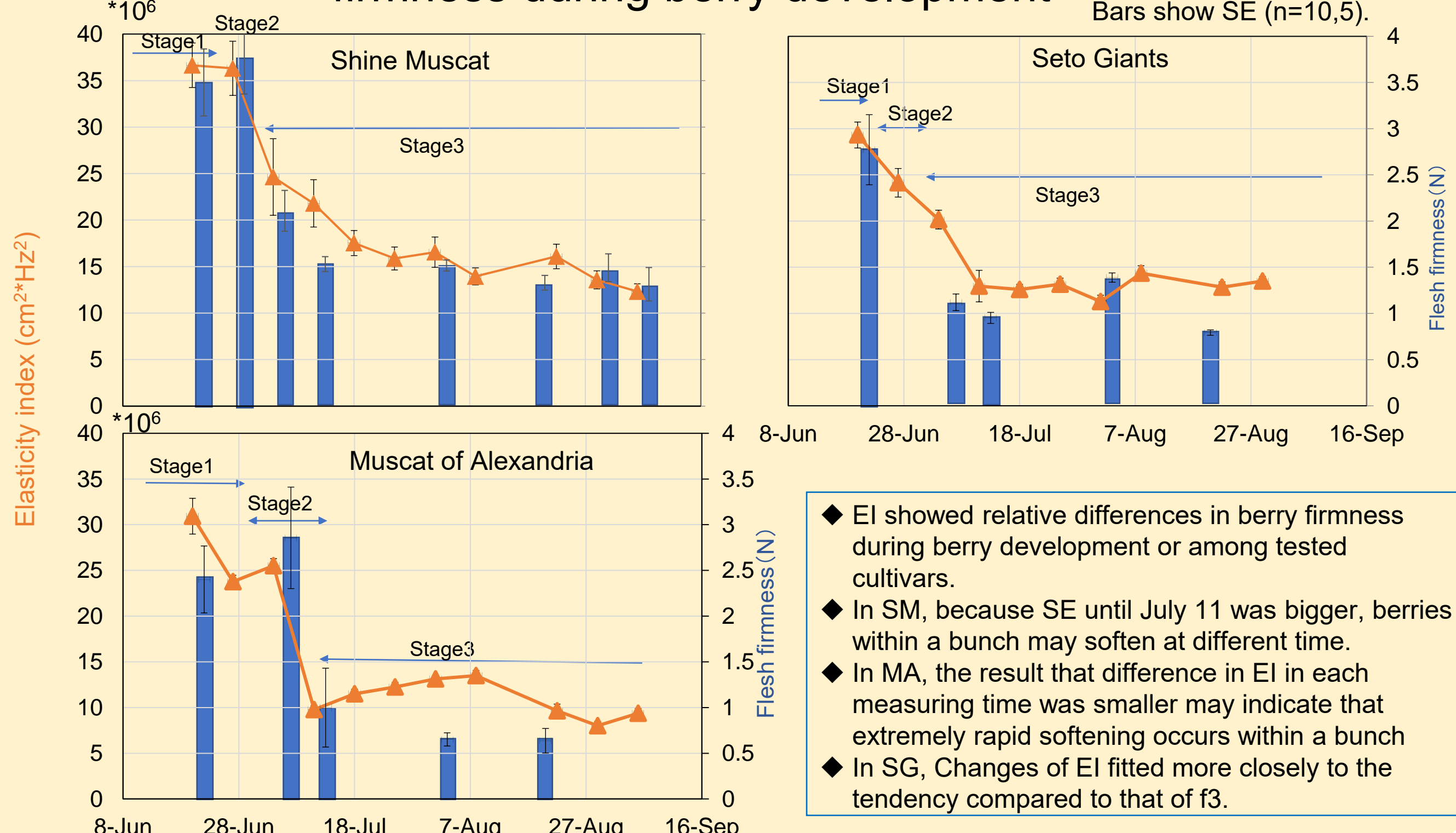
Berries may additionally soften toward mature stage and promote its sugar accumulation and acid reduction.



Appearance of berries



### Comparison between tendencies of elasticity index (EI) and flesh firmness during berry development



## Conclusion

Using this simple method with a mobile acoustic vibration instrument, changes in flesh firmness during berry development could be presumed nondestructively. Decline patterns of f3 or EI were obviously different among three cultivars.

Additional decline of berry EI were revealed since late August in SM and MA, which showed rapid sugar accumulation until the harvest time. We must investigate their relationships to the maturity in more detail.

**This acoustic vibration method may evaluate the trend of berry softening nondestructively in grape.**

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