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# Basic study on measurement of tissue sound speed and attenuation by opposed planar transducer and matrix array probe

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## 1. Introduction

The propagation speeds of elastic waves in tissues are effective physical quantities for evaluating tissue properties. Bone density measurement using the propagation speed of the longitudinal wave in trabecular bone [1] and liver stiffness measurement using the propagation speed of the shear wave in the liver [2] are applied in clinical practice.

In this study, a measurement system of the acoustic transmission characteristics in the body is proposed. By transmitting ultrasound pulses as plane waves from a planar transducer and receiving the pulses that passed through the object with a matrix array probe placed on the opposite side, the sound speed and attenuation in the object can be measured with high spatial resolution. In this report, the sound speed and attenuation of pork were measured to evaluate the performance of the measurement system.

## 2. Method

### 2.1 Measurement system of acoustic transmission characteristics

The configuration of the measurement system is shown in **Fig. 1**. The transmission planar transducer (3 MHz, 20 mm diameter, Honda Electronics) is mounted on goniometer stages for the X- and Y-axes, while the receiving matrix array probe (3 MHz, 32 × 32 elements, Vermon) is connected to the Z-axis motorized stage via the resin fixture. The input to the plane transducer was a 3 MHz one-cycle sinusoidal wave, and the applied voltage was 20 V. The matrix array probe received and stored the transmitted ultrasound by the research ultrasound system (Vantage 256, Verasonics) with a sampling frequency of 11.9 MHz.

### 2.2 Procedure of the measurement

First, the alignment and spacing between the transducer and the probe were adjusted. Then, the object was placed between the transducer and the probe, and the ultrasound pulse that passed through the object was recorded. Afterword, the space between the transducer and the probe was filled with water through an 8 μm-thick polyethylene film, and the ultrasound pulse that propagated over a distance equal to the thickness of the object was recorded.

The sound speed in water was estimated by gradually varying the space between the transducer and the probe. The sound speed in the object was estimated from the difference in the reception times of the ultrasound pulses and the sound speed in water. The attenuation was estimated from the difference in amplitudes of the ultrasound pulse that passed through the object and the ultrasound pulse that propagated in water.

### 2.3 Measurement object

The pork samples and the measurement areas are shown in **Fig. 2**. The thicknesses of the pork samples were 15 mm and 12 mm, respectively.

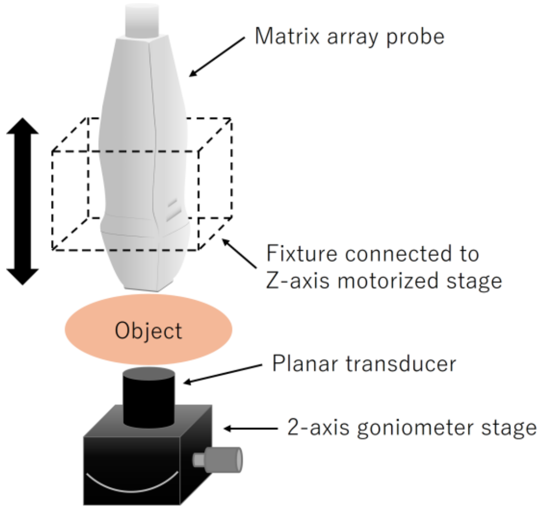
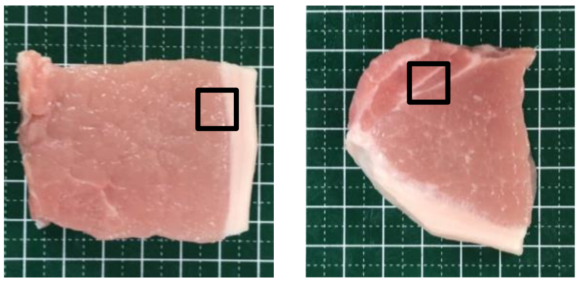



Fig. 1 Measurement system of acoustic transmission characteristic with a planar transducer and a matrix array probe positioned opposite each other.



(a) (b)

Fig. 2 Pork samples and measurement areas.

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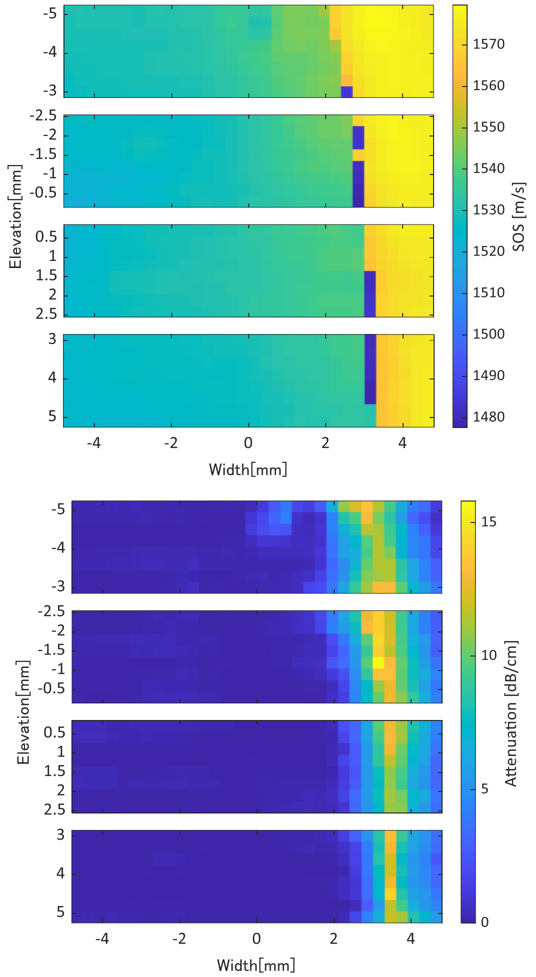


Fig. 3 Sound speeds and attenuations of the pork sample (a).

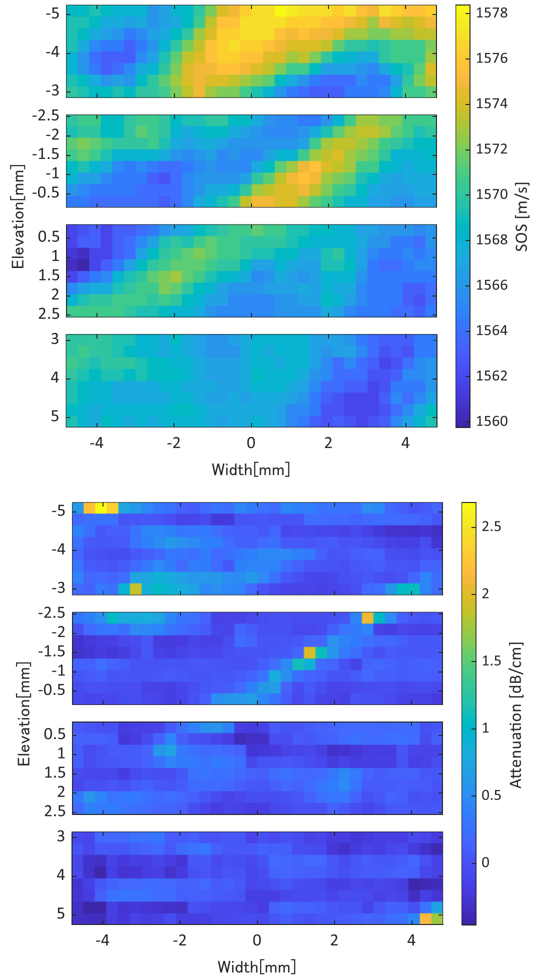


Fig. 4 Sound speeds and attenuations of the pork samples (b).

## 3. Result and discussion

The sound speeds and attenuations of the pork sample (a) are shown in **Fig. 3**. The sound speeds in the lean part (left side) were approximately 1540 m/s, while in the fatty part (right side), they were approximately 1580 m/s. The temperature of the pork sample (a) during the measurement was 15°C. At this temperature, the sound speed in the fatty part is higher than that of the lean part. Attenuations were particularly large at the tissue boundaries due to the distortion of the waveforms. It was suggested that to accurately measure attenuation, it is necessary for the ultrasound to pass through a sufficiently large area.

The sound speeds and attenuations of the pork samples (b) are shown in **Fig. 4**. The sound speeds in the lean part were increased to approximately 1570 m/s, while in the fatty part, they were slightly lower than 1580 m/s. The temperature of the pork sample (b) during the measurement was 22.1°C, and the sound speeds in the lean part increased while the sound speed in the fatty part decreased. Regarding attenuations, it increased around the fatty part, but it is difficult to determine whether this attenuation is due to the fat itself or to the tissue boundaries.

## 4. Conclusion

For evaluating the performance of the measurement system of acoustic transmission characteristics, the sound speed and attenuation of pork were measured. It was suggested that the possibility of tissue characterization based on the sound speed and attenuation was indicated.

**Acknowledgment**

This work was partly supported by JSPS Core-to-Core Program JPJSCCA20240003.

**References**

1) Matsukawa M., *et al.*, IEICE Fundamentals Review, Vol.3, No.4, pp. 47-52, 2010.
2) Shiina T., J Med Ultrasonics, Vol. 40, No. 4, pp. 309-323, 2013.