

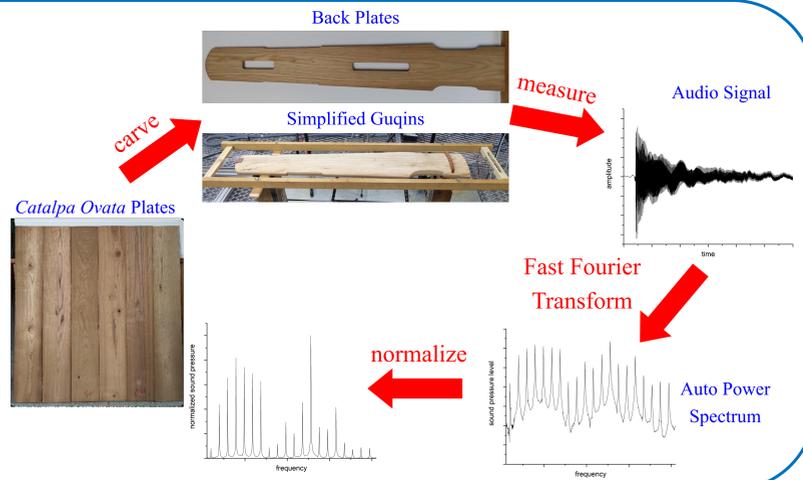
The Vibrational Properties of *Catalpa Ovata*

Wood for the Back Plate of the Guqin

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Introduction

Catalpa ovata is the traditional material of the back plate of the guqin, a Chinese seven-string zither known for its long history. Since there is a lack of scientific and systematic method of selecting materials of guqin, the guqin luthiers' experience and craftsmanship dominate the procedure. Thus, the aim of this research is evaluate the effects of back plate materials on the sound characteristic of guqin, and trying to form a basis for choosing materials in the future.



Materials

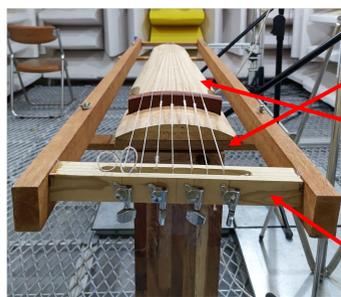
- Materials were 12 *Catalpa ovata* plates, numbered A to L by density, and 1 *Firmiana simplex* plate.

	Density (kg/m ³)		Speed of Sound (10 ³ *m*s ⁻¹)		Sound Radiation Coefficient (m ⁴ *s ⁻¹ *kg ⁻¹)		Loss Coefficient (%)
	D	C _L	C _T	R _L	R _T	η	
A	431.41	4.39	1.20	10.18	2.78	1.76	
B	483.18	4.36	1.20	9.02	2.48	1.79	
C	483.18	3.88	1.37	8.03	2.83	1.96	
D	509.06	4.49	1.22	8.82	2.39	1.73	
E	532.79	4.11	1.14	7.71	2.13	1.97	
F	543.57	4.81	1.13	8.85	2.08	1.63	
G	550.04	4.09	1.20	7.44	2.19	1.86	
H	567.30	4.38	1.20	7.72	2.12	1.73	
I	575.93	4.78	1.11	8.31	1.93	1.73	
J	575.93	4.39	1.27	7.63	2.21	1.85	
K	601.81	4.66	1.24	7.74	2.07	1.64	
L	616.91	4.77	1.25	7.73	2.02	1.64	
*C.V (%)	10.07	6.72	5.72	9.80	12.85	6.56	
<i>Firmiana simplex</i>	280.97	4.42	1.22	15.73	4.35	0.70	

*C.V: Coefficient of Variation

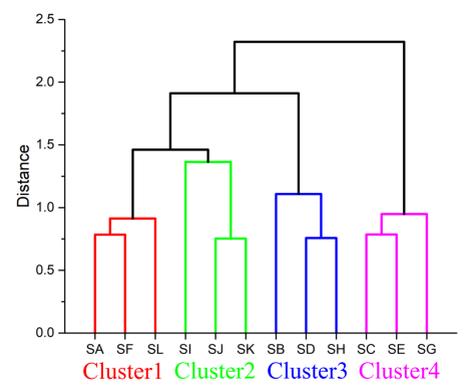
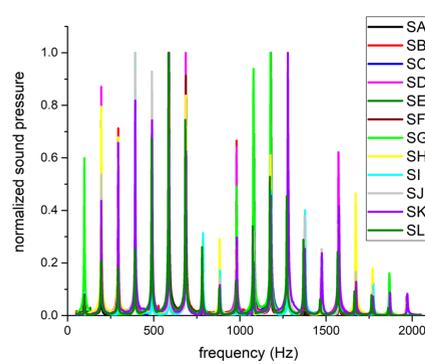
Making Simplified Guqins

- Simplified guqins were assembled with a audition frame by 12 back plates and 1 top plate without finishing respectively.
- According to back plates, simplified guqins would number SA to SL.



Plucking the 4th String

- There were 20 harmonics between 0–2000 Hz.
- Using clustering analysis could merge the simplified guqins which had the similar spectral features into 4 clusters.



Measurement

- Sound of simplified guqins were measured by a microphone in the anechoic chamber.
- Measurement items:

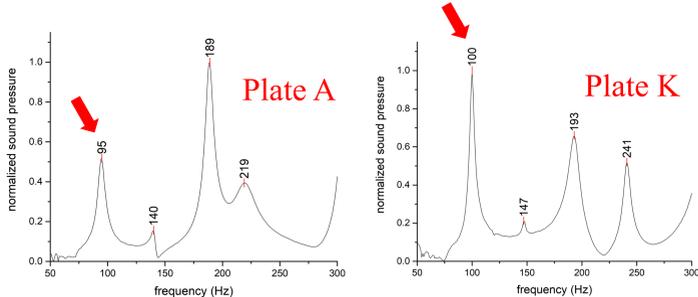
- Knocking on simplified guqins;
- The highest resonant frequency of strings and simplified guqins;
- Plucking the 4th string (98 Hz).

Microphone



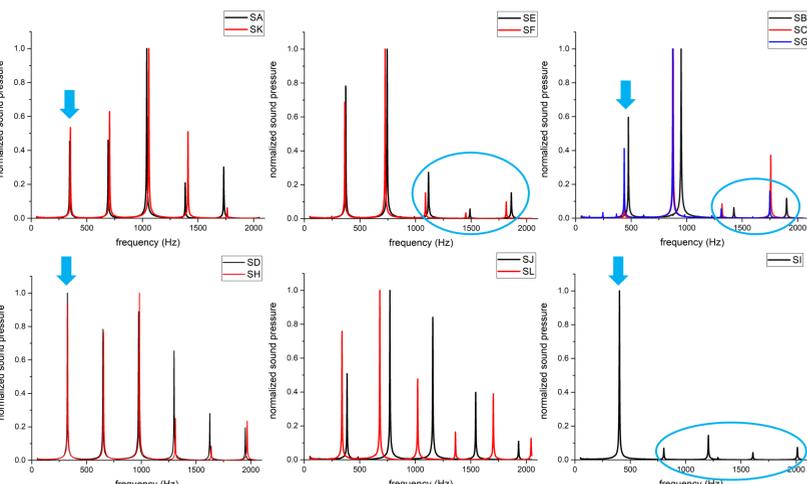
Knocking on Simplified Guqins

- The fundamental frequency of simplified guqin with low-density back plate was lower.
- Knocking on the simplified guqins formed the basis of evaluating materials for guqin luthiers; however, the spectral features were messy and disturbed by unnecessary signal.



The Highest Resonant Frequency

- SA was similar to SK; SD was similar to SH; SJ was similar to SL; SE was similar to SF; SB, SC and SG had similar spectrum.
- Comparing the peak frequency, SA, SK, SD and SH had lower fundamental frequency; SB, SC, SG and SI had higher fundamental frequency, but the peak values in high-frequency field were small.

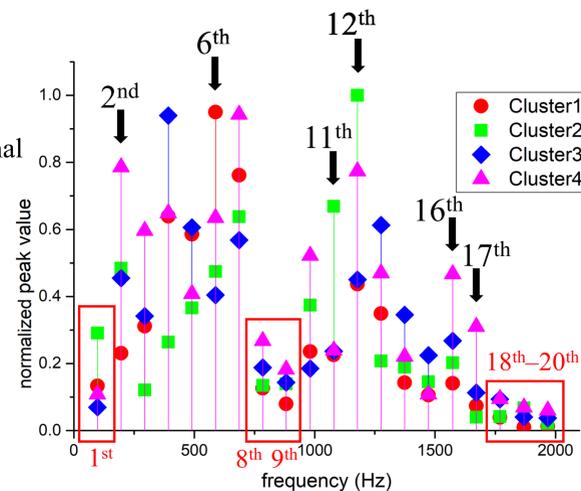


- According to the result of ANOVA, peak values of the 2nd, 6th, 11th, 12th, 16th and 17th harmonics had significant difference between clusters (p-value < 0.05), and peak values of the 1st, 8th, 9th, 18th, 19th and 20th harmonics had no significant difference.

- Peak values of the 1st, 8th and 9th harmonics were small, which might be the characteristics of simplified guqins, and the frequency range above the 18th harmonics were too high for resonance.

- Cluster2 had the most apparent peaks in 1100–1200 Hz but decreased in higher frequency immediately; Cluster4 had the most apparent peaks in 200–300 Hz and 1600–1700 Hz.

- Comparing these 2 clusters, Cluster2 (SI, SJ, SK) had higher density and longitudinal speed of sound; Cluster4 (SC, SE, SG) had higher loss coefficient and transverse sound radiation coefficient.



Conclusion

- Knocking on the materials can find the fundamental frequency immediately, but it is disturbed easily.
- According to the highest resonant frequency, SA is similar to SK; SD is similar to SH; SJ is similar to SL; SE is similar to SF; SB, SC and SG have similar features.
- Resulting from the spectrums of plucking the 4th string, peak values of the 1st, 8th, 9th, 18th, 19th and 20th harmonics of simplified guqins are small.
- Comparing Cluster2 and Cluster4, the back plates which have lower density and higher transverse sound radiation coefficient might resonate in wider frequency range.