The Hasapi of the Batak Toba from Sumatra Indonesia

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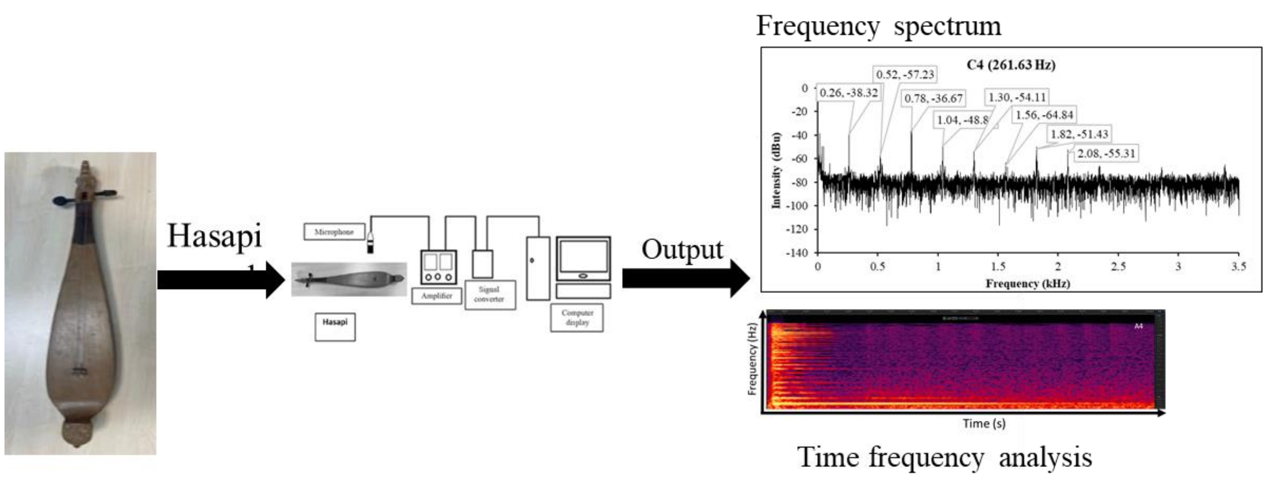
GRAPHICAL ABSTRACT



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The hasapi of the Batak Toba from Sumatra, Indonesia is a plucked bowl-lute chordophone. Hasapi is a fretless chordophone with two strings. The tuning for the hasapi used in this study is based on the transcription of the song 'Horbo Paung' played in F major by Sam Sitio. The tuning used for the 2nd string is C4 (Do for open string) followed by D4, E4, and F4 for 1st, 2nd, and 3rd finger, respectively. The 1st string was tuned to G4 (So for open string), followed by A4, B4, and C5 for 1st, 2nd, and 3rd finger, respectively. At higher notes (1st string) the spectra did not display many harmonics, *i.e.*, less partials compared to the lower note (2nd string). Both strings showed a regular signal, whereas the highest note C5 (the highest fundamental frequency from the 1st string) showed an irregular pattern with no significant overtone frequency. The intensity of the partials in both strings displayed the reduction in amplitudes i.e. not proportional to increasing harmonic frequency. The timbre from Adobe Audition showed that the time frequency analysis (TFA) was in accordance with the Picoscope spectra. Only TFA from C5 showed irregular pattern with respect to the Picoscope output.

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Keywords: Hasapi; Bowl-lute chordophone; Batak Toba; Sumatra

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INTRODUCTION

The Batak Toba of northern Sumatra, Indonesia manufactures two-stringed lutes known as hasapi. The hasapi is a plucked bowl-lute chordophone (Kartomi 1984; Yampolsky 1992; Perlman 2013). In the past, the hasapi had been played solo in religious ceremonies and as a courtship instrument. Today it is used in uning-uningan (a small secular entertainment ensemble) in the Batak Toba community. Uning-uningan is a term for traditional Batak Toba musical instruments. It is more common for the Hasapi to be played as part of an ensemble, often accompanied by other traditional instruments, in both ceremonial and entertainment settings. Figure 1 shows the uning-uningan of Batak Toba musical instruments.

Fig. 1. The uning-uningan of Batak Toba musical instruments

In general, uning-uningan musical instruments consist of 3 sections:

1. Wind instruments: Talatoit (tulila or salohat), sulim, sarune, sordam
2. String instruments: Tanggetang, hasapi, mengmung
3. Percussion instruments: Gendang, odap, hesek, taganing, gong, garantung, jenggong, sagasaga

Figures 2, 3, and 4 show Taganing and Garantung, Hesek and Sarune, and Gendang and Gong, respectively.

Fig. 2. Taganing and garantung

Fig. 3. Hesek and sarune

Fig. 4. Gendang and gong

Today, hasapi are part of musical ensembles that include flutes, small drums, xylophones, and various other instruments. Traditionally it is used indoors, but an electric version of the hasapi also exists. Hasapi, known as kacapi, hapitan, or kulcapi, is a two-stringed lute of Batak Toba people from Sumatra Indonesian (Sibeth and Carpenter 2007). It was used for Zere religious rituals but now is used in the orchestra for the traveling theater 'Opera Batak'. Unlike gong orchestras (used for large outdoor events), hasapi are used in indoor settings and are generally played in musical ensembles. Hasapi is manufactured from Kassod Tree, *Senna siamea* (also called *Cassia siamea* local name Petai Belalang) from family of Fabaceae (Leguminosae). *Senna siamea* is a medium-sized tree with a dense, rounded crown that becomes spreading and irregular at maturity. It is an evergreen tree growing up to 18 m with yellow flowers. It grows in lowland forests, riverbanks, and in waste areas and along roadsides. The trunk is short, and the low-branching trunk has grey, smooth bark.

Fig. 5. Kassod tree, *Senna siamea* (also called *Cassia siamea* local name Petai Belalang)

The wood possesses a moderate to heavy weight, exhibiting a high level of hardness, and is highly resistant to termites. It is characterized by its strength, durability, and challenging workability. The heartwood of the wood exhibits a medium brown and red color, occasionally with a reddish or yellowish tint, and is characterized by practically black streaks. The grain of the material is linear, exhibiting a highly rough texture. The wood possesses exceptional strength, hardness, and a sufficient black hue to serve as a viable alternative to ebony. Sapwood and heartwood exhibit distinct color variations; sapwood appears as a pale-yellow shade, while heartwood ranges from yellowish-brown to blackish brown. The woodgrain can exhibit either an interlocking or wavy pattern, accompanied by a rough texture. The pores of this wood are naturally saturated with sap from the tree, resulting in a smoother surface compared to other woods with larger, more open pores. The wood possesses a high density and weight, with an average mass of approximately 810 kg/m^3 when it is dry. The volume shrinkage coefficient is 0.62. The fiber saturation point is 23%. The pressure strength parallel to the grain, static bending strength, and splitting strength are 615 kg/cm^2, 1520 kg/cm^2, and 20 kg/cm, respectively. The collision resulted in a bend of 0.64. *Senna siamea* wood is suitable for applications in construction and transportation that demand exceptional endurance. Thus, it is an excellent variety of lumber, characterized by its straight and robust grain. It possesses durability and is resistant to weather conditions. Under normal circumstances, it is improbable for it to deform or get molded.

Hasapi is a fretless chordophone with two strings. Today, Jackfruit (*Artocarpus heterophyllus*, a species of tree of the mulberry family Moraceae) trees are used. There are 2 types of tuning for hasapi. The first tuning used the 2nd string tuned to 'Do' and the 1st string tuned to 'Mi' (Adelia *et al*. 2021). This tuning is used for ritual occasions or events. The second tuning used the 2nd string tuned to 'So' and the 1st string tune to 'Re' (https://youtu.be/HPjN4rGyaM4?si=X1UN-UgTqY-Jrbft and further demonstration is provided at https://youtu.be/FxtNsY9RTvk?si=cp5I_5x9wh_wS6st). This tuning is used for entertainment occasions or events. The hasapi shape is unique because the resonator hole is at the back of the instrument body such that when playing the sound is directed to the belly/tummy of the player (in Batak Toba it is called Parhasapi). This influences the sound.

The composition of the ensembles varies. Typically, the ensembles include a lead hasapi for the melody and a second hasapi for accompaniment, a flute, small drum, xylophone, and other instruments. In the olden day, Batak Toba music was sacred and played as part of a love magic ritual to win a woman's affections. Today, because all Batak Toba are Christians, hasapi music is used for secular entertainment. Contemporary musicians in some regions have even created electric versions of the lute, which give far greater amplification to its normally subtle tones.

There are two types of hasapi based on its purpose, namely hasapi ende (or indung) and hasapi doal. Hasapi ende functions as a melody, normally slightly bigger and Hasapi doal functions as a drone and sounds similar like a gong that plays the rhythm and is normally slightly smaller than hasapi ende. Hasapi is used in hasapi gondang ensemble, where it functions as ritual events in the Batak Toba community. Hasapi gondang ensemble includes hasapi ende, hasapi doal, sarune etek, and garantung dan hesek. In uning-uningan ensemble in the Batak Toba community, hasapi is used for performing 'Batak opera', which includes sulim, taganing, sarune etek, garantung, and hesek instruments. The neck and body are lightly ornamented, and the headstock is carved in the shape of a bird, which is related with magical symbolism (Simon 1984a, 1984b, 1985). At the backside of the instrument's foot, the mask-like zoomorphic image is carved into the body. The general shape of this instrument is like a boat lute due to the resemblance between its profile and that of boats found in areas of Indonesia.

The hasapi is constructed from a solitary piece of timber. The instrument features a 30-cm-long chamber at its bottom end, which is excavated and covered with a securely attached, extremely thin piece of wood that functions as the soundboard. The resonator's rear surface features a sound hole that is elongated with teardrop-shaped, measuring 10 cm in length. Located directly beneath the little pegbox is a sleek, level section made of horn that functions as a fingerboard without frets. Positioned above the pegbox is an intricately carved avian sculpture, crafted from the same piece of wood as the rest of the instrument. Adjacent to the lower part of the soundboard, there is a wooden block that is affixed in place. This block has a square shape and is designed to function as both the bridge and the holder for the strings. The instrument features two wire strings that extend from the bridge to the upper edge of the fingerboard, which acts as a nut. These strings are then wrapped around the ends of the two friction tuning pegs, with one peg located on each side of the pegbox. The instrument is positioned horizontally across the performer's abdomen, and the strings are plucked with the performer's right hand. The left hand's fingertips are employed to press down on the strings against the fingerboard that lacks frets. The Toba Batak 'uning-uningan' ensemble utilizes one or more hasapi instruments to either perform tunes or give a strummed rhythmic accompaniment. The hasapi that fulfils the previous job are referred to as hasapi taganing, whereas the others are known as hasapi doal. While the origin of the hasapi is commonly attributed to the Batak Toba people of Northern Sumatra, the exact timeframe of its emergence remains uncertain.

The distinctive feature of Hasapi music is the sound hole, which is at the back rather than the front like it is on a guitar. A string tie bridge, sound hole, finger board or press board, neck, tuning pegs, and head are among the almost identical elements of hasapi musical instruments. Nevertheless, unlike guitars, hasapi musical instruments lack gap holes and frets on the fingerboard's neck (Pandiangan *et al*. 2021). Additionally, Hasapi does not have a fret metal like the guitar but usually fills it with glass (Adelia *et al*. 2021). Today, dried jackfruit wood is used to make hasapi. Jackfruit wood was selected for its strength, durability, and ability to generate a loud, pleasing tone. There is a single, curved sound hole at the rear of the Hasapi musical instrument resonator box, which is used to alter the sound to appear more resonant (Pandiangan *et al*. 2021).

Hasapi serves as a melody carrier in the gondang game, which parallels the structure of the sulim or garantung melodic game (Pandiangan *et al*. 2021). Hasapi plays an important role in Gondang Hasapi ensemble for ritual. It can help the society to reach the God Almighty (Siburian 2019). The 'mamiltik' method, formerly known as 'tukkel' (plucked), is the way used to play hasapi musical instruments. Playing a hasapi is like playing a guitar in general in that the left hand is used to find the tone on the hasapi's neck, and the right hand is used to pluck with a pick and can sustain and hold notes. Although no training is required for hasapi musicians, it is simpler for someone who played guitar in the past to become proficient (Adelia *et al*. 2021). The melody of hasapi is mostly known in pentatonic group of scales (Adelia *et al*. 2021). However, the capability of hasapi can extend to diatonic with a system fingering. The motive of melody played by hasapi player is usually in repetitive motive and short as by hasapi notation 'Horbo Paung' played by Sam Sitio (Sam Sitio 2020) in Fig. 6. The melodic playing pattern is typically mixed with filler (tone and motif variations) between the main melody (Adelia *et al*. 2021). By referring to the motive development techniques in music, the phrase motive is repeated frequently, and the motive is developed involving rhythmic changes, fragmentation, and extension. The playing style of Hasapi is also in allegro tempo. Its melody often being transcribed in semiquaver or 16th notes value. The melodic playing is also influenced by the motive development fragmentation, a part of the motives is repeated and varied, which is also found in the technique of Hadyn and Beethoven.

Fig. 6. Example of hasapi notation Harbo Paung played by Sam Sitio

EXPERIMENTAL

The vibrations produce sound waves that create the notes heard in music. Several factors influence the sound generated, including the tension, and the position of the finger (it is fretless). To ensure a consistent position of the finger, a point is marked on the smooth, flat piece of horn that serves as a fingerboard by a skilled professional player well-versed in these nuances. The audio signals were captured in monaural format with a sampling rate of 48 kHz and a resolution of 24 bits. The audio profile was saved in wave format for later processing. The calibration process confirmed that the recording system was set up properly, ensuring that the audio signals would be recorded at the optimal levels. This calibration procedure was crucial to maintaining the integrity of the recorded signals and producing high-quality audio recordings free from distortions and clipping. Before the session was recorded, a calibration was done to make sure the recording settings were ideal. The following steps were included in the calibrating process:

1. Test Tone Generation: To facilitate calibration, a test tone with a sine wave frequency of 1.0 kHz was created. The European Broadcasting Union (EBU) technique for standard calibration was used in choosing this frequency.
2. Output Level Adjustment: The calibration means that the device outputs a digital recording level of 0 VU in accordance with the EBU requirements. This translates to either -18 dBFS in digital format or +4 dBu in analog format.
3. Equipment Isolation: To avoid interfering with the signal amplitude during calibration, all nearby equipment was either switched off or isolated.
4. Recording System Configuration: The recording system was equipped with the following devices: -Interface for audio: Steinberg UR22mkII
    a. Audio-Technica AT4050 microphone - Behringer Powerplay Pro XL amplifier
    b. Cables: XLR connectors.
5. Configuring the Microphone: A low-cut filter was applied to the Audio-Technica AT4050 microphone to remove undesired low-frequency noise.

The size and feature of the hasapi is shown in Fig. 7. The size of the resonance chamber from the cross-sectional of the front and rear of the instrument is also provided in the figure. The wall thickness is 3.6 mm. In this study, the experiment was conducted by plucking the strings. The 2 strings used are violin strings D and A for 2nd and 1st strings, respectively (brand name Pyramid). The radiated sound was measured with an omni directional microphone placed 20 cm above the hasapi and was completed in an anechoic chamber.

The time signals obtained from PicoScope oscilloscopes and data recorders for real-time signal acquisition were viewed and analyzed using the PicoScope computer software (Pico Technology, 3000 series, Eaton Socon, UK). The PicoScope program facilitates analysis through the utilization of Fast Fourier Transform (FFT), a spectrum analyzer, voltage-based triggers, and the capability to save and retrieve waveforms. The schematic diagram of the experimental setup is depicted in Fig. 8. The sound capture was sufficiently loud to be detected by the signal converter, facilitated by the amplifier (Behringer Powerplay Pro XL, Behringer, Zhongshan, Guangdong, China). The sound spectra are acquired by measurements conducted using PicoScope. Following the capture and recording of the sound data, the FFT was analyzed using Adobe Audition (for time frequency analysis (TFA)) to determine the dominant frequency for each tone at a certain moment. Fourier transformation is a mathematical technique used to identify fundamentals, harmonics, and subharmonics.

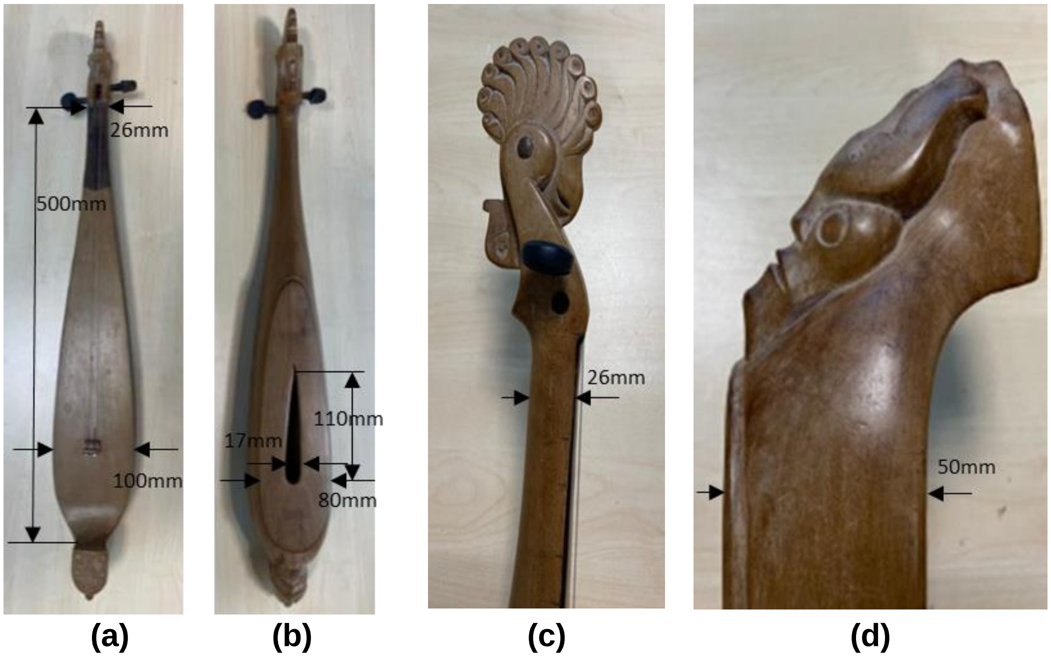


Fig. 7. The hasapi used in this study: (a) front view; (b) rear view; (c) bird head; (the anthropomorphic figure above the pegbox); and (d) human head (the zoomorphic figure at the backside of the instrument's foot)

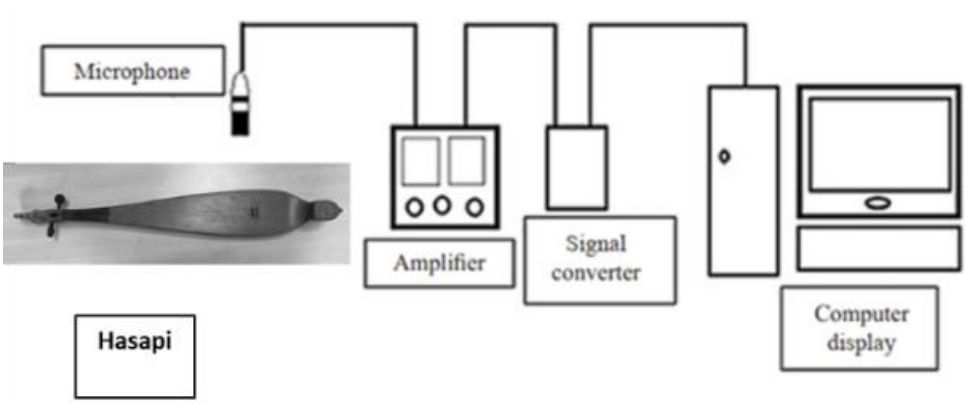
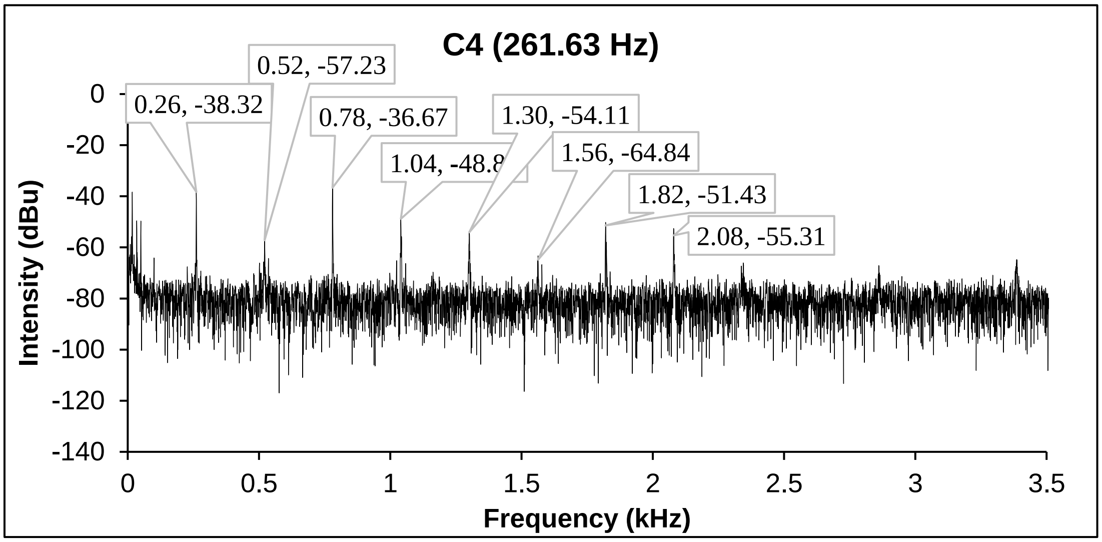
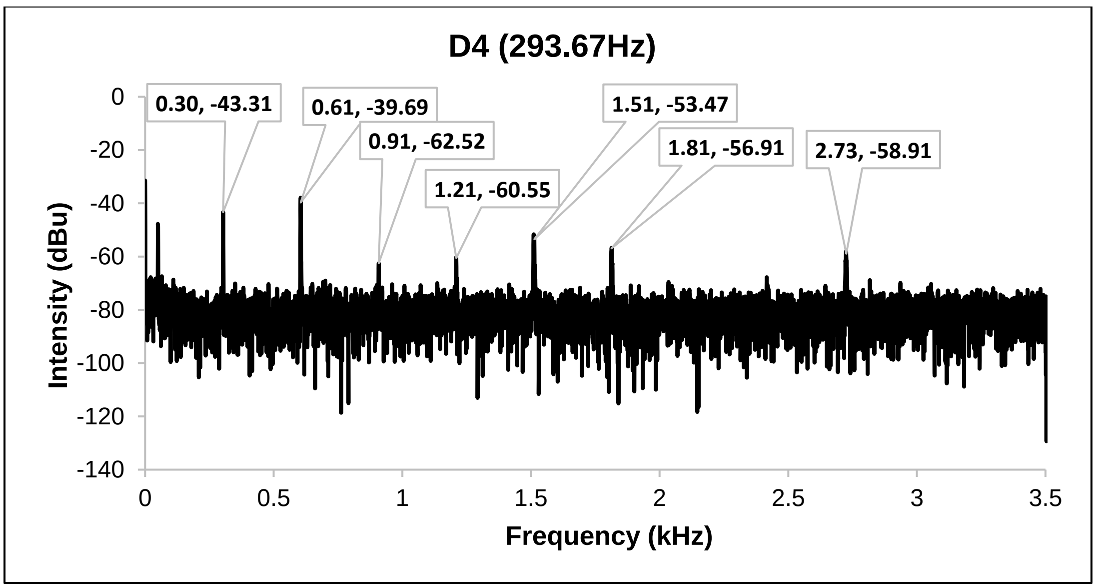


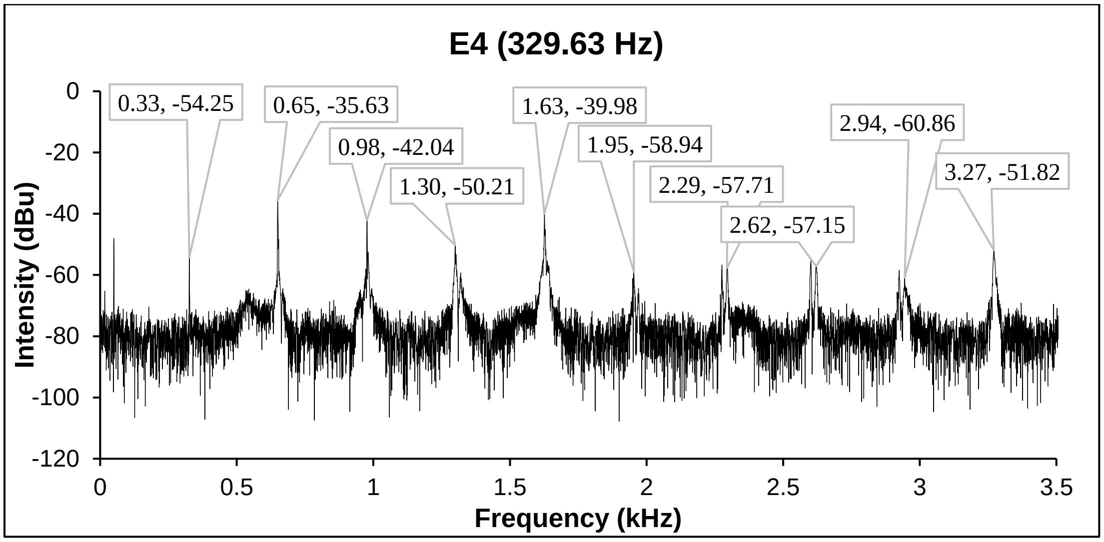
Fig. 8. Schematic diagram of the experimental setup

RESULTS AND DISCUSSION

Figure 9 shows the FFT spectra from string 2, C4 (261.63 Hz-open string), D4 (293.67 Hz-1st finger), E4 (329.63 Hz-2nd finger), and F4 (349.23 Hz-3rd finger). Figure 10 shows the FFT spectra from string 1, G4 (392.00 Hz-open string), A4 (440.00 Hz-1st finger), B4 (493.88 Hz-2nd finger), and C5 (523.25 Hz-3rd finger). Table 1 shows the partials for every note from 2nd and 1st strings. Figure 11 shows the partial frequency (kHz) *versus* harmonic number (harmonic number 1 is the fundamental frequency).







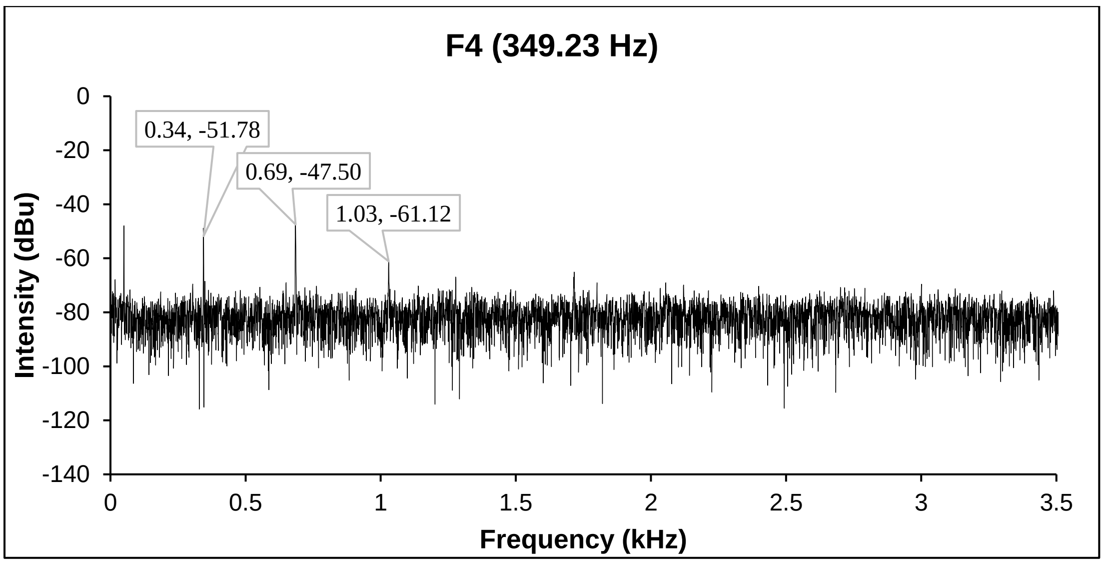
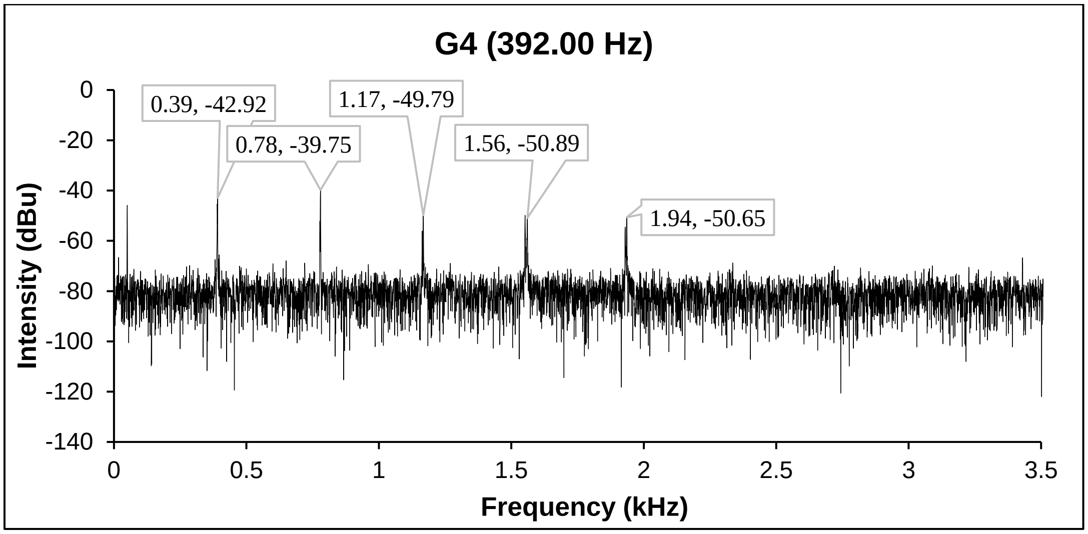
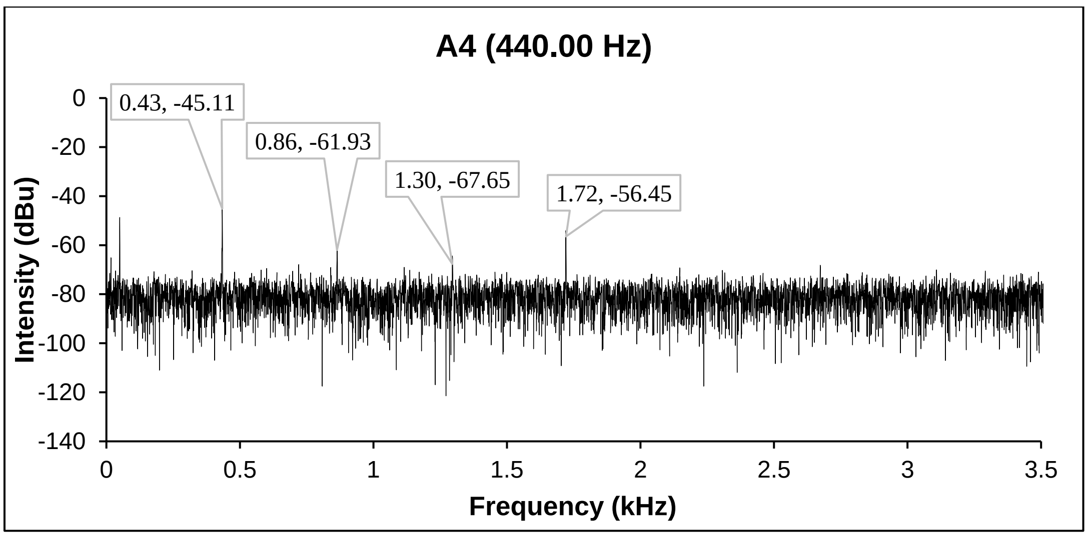
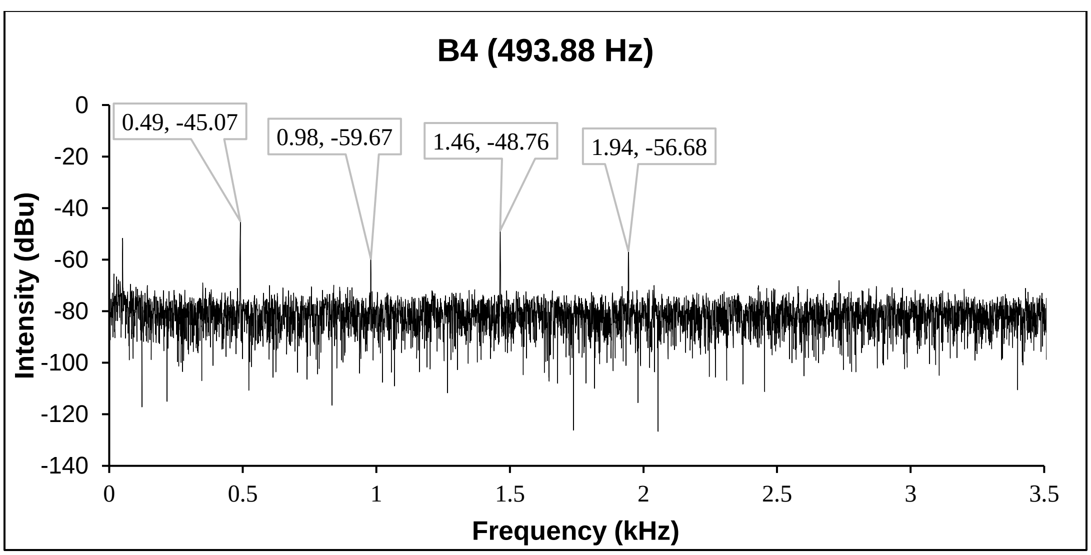


Fig. 9. The FFT spectra from the 2nd string, C4 (261.63 Hz-open string), D4 (293.67 Hz-1st finger), E4 (329.63 Hz-2nd finger), and F4 (349.23 Hz-3rd finger)


G4 (392.00 Hz)
Intensity (dBu)
Frequency (kHz)
0.39, -42.92
0.78, -39.75
1.17, -49.79
1.56, -50.89
1.94, -50.65


A4 (440.00 Hz)
Intensity (dBu)
Frequency (kHz)
0.43, -45.11
0.86, -61.93
1.30, -67.65
1.72, -56.45


B4 (493.88 Hz)
Intensity (dBu)
Frequency (kHz)
0.49, -45.07
0.98, -59.67
1.46, -48.76
1.94, -56.68

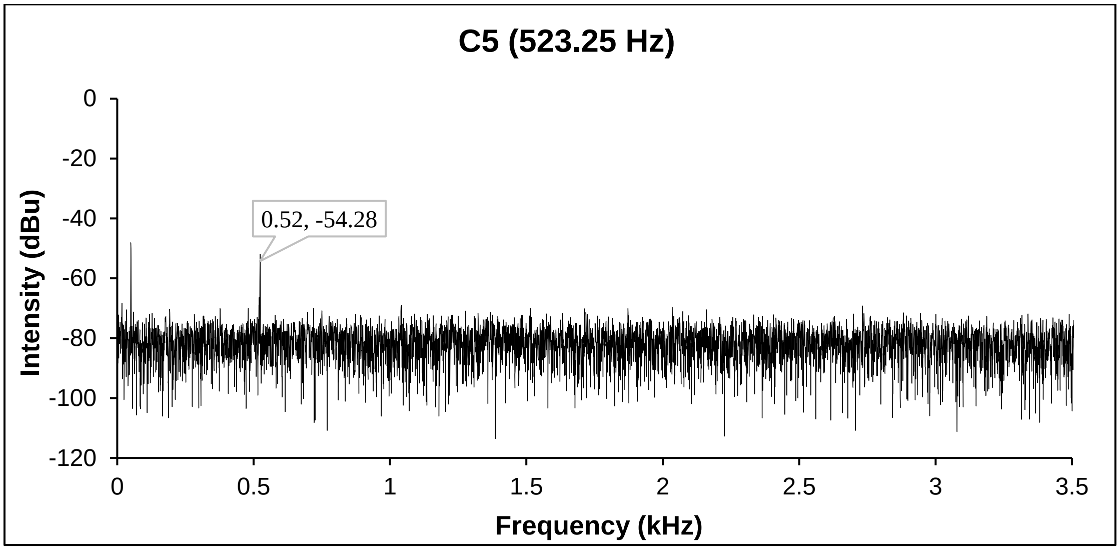


Fig. 10. The FFT spectra from 1st string, G4 (392.00 Hz-open string), A4 (440.00 Hz-1st finger), B4 (493.88 Hz-2nd finger), and C5 (523.25 Hz-3rd finger)

Table 1. Partials Frequency (kHz) (from 1st to 10th partials) for Every Note from 2nd and 1st Strings

String	Note	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
2nd String	C4 (261.63 Hz)	0.26	0.52	0.78	1.04	1.30	1.56	1.82	2.08	-	
	D4 (293.67 Hz)	0.30	0.61	0.91	1.21	1.51	1.81	2.73	-	-	
	E4 (329.63 Hz)	0.33	0.65	0.98	1.30	1.63	1.95	-	2.62	2.94	3.27
	F4 (349.23 Hz)	0.34	0.69	1.03	-	-	-	-	-	-	
1st String	G4 (392.63 Hz)	0.39	0.78	1.17	1.56	1.94	-	-	-	-	
	A4 (440.00 Hz)	0.43	0.86	1.30	1.72	-	-	-	-	-	
	B4 (493.88 Hz)	0.49	0.98	1.46	1.94	-	-	-	-	-	
	C5 (523.25 Hz)	0.52	-	-	-	-	-	-	-	-	

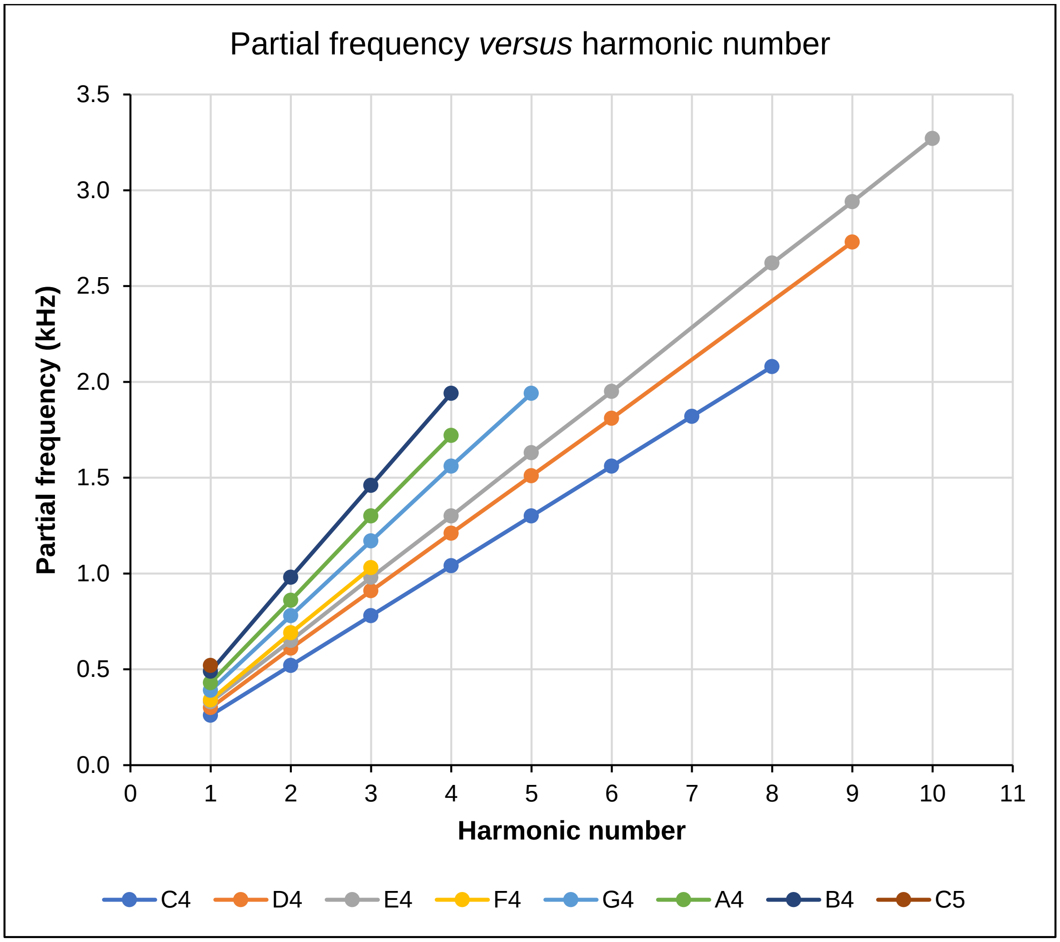


Fig. 11. Partial frequency (kHz) *versus* harmonic number (Harmonic number 1 is the fundamental frequency)

From Fig. 11, 2nd string, C4 had 8 partials, D4 had 7 partials with missing harmonic numbers 7 and 8, whereas E4 had 9 partials with missing harmonic number 7. F4 had only 3 partials. From Fig. 11, 1st string, G4 had 5 partials followed by A4 and B4 with only 4 partials. C5 had only 1 partial. Although all strings and notes display harmonic frequency, some harmonics are missing at higher frequencies (D4 and E4). Higher notes only display a few harmonics compared with lower note. C5 did not display any overtone, *i.e.*, only the fundamental frequency. The open string in 2nd string (C4) displays a maximum of 8 partials and a minimum of 3 partials at note F4. The open string in 1st string (G4) displays a maximum of 5 partials only and a minimum of 1 partial at C5. The 2nd string had more harmonics than the 1st string. At higher note (1st string) the spectra did not display many harmonics, *i.e.*, less partials compared to lower note (2nd string) because the high frequency was absorbed by the wooden resonator. Both strings showed a regular signal whereas the highest note C5 showed an irregular pattern with no significant overtone (only the fundamental frequency). The intensity of the partials in both strings display an irregular pattern *viz.*, a reduction of intensity (amplitudes) is not proportional to increasing harmonic frequency of the string. Figures 12 and 13 show the TFA for 2nd string and 1st string from Adobe Audition, respectively.

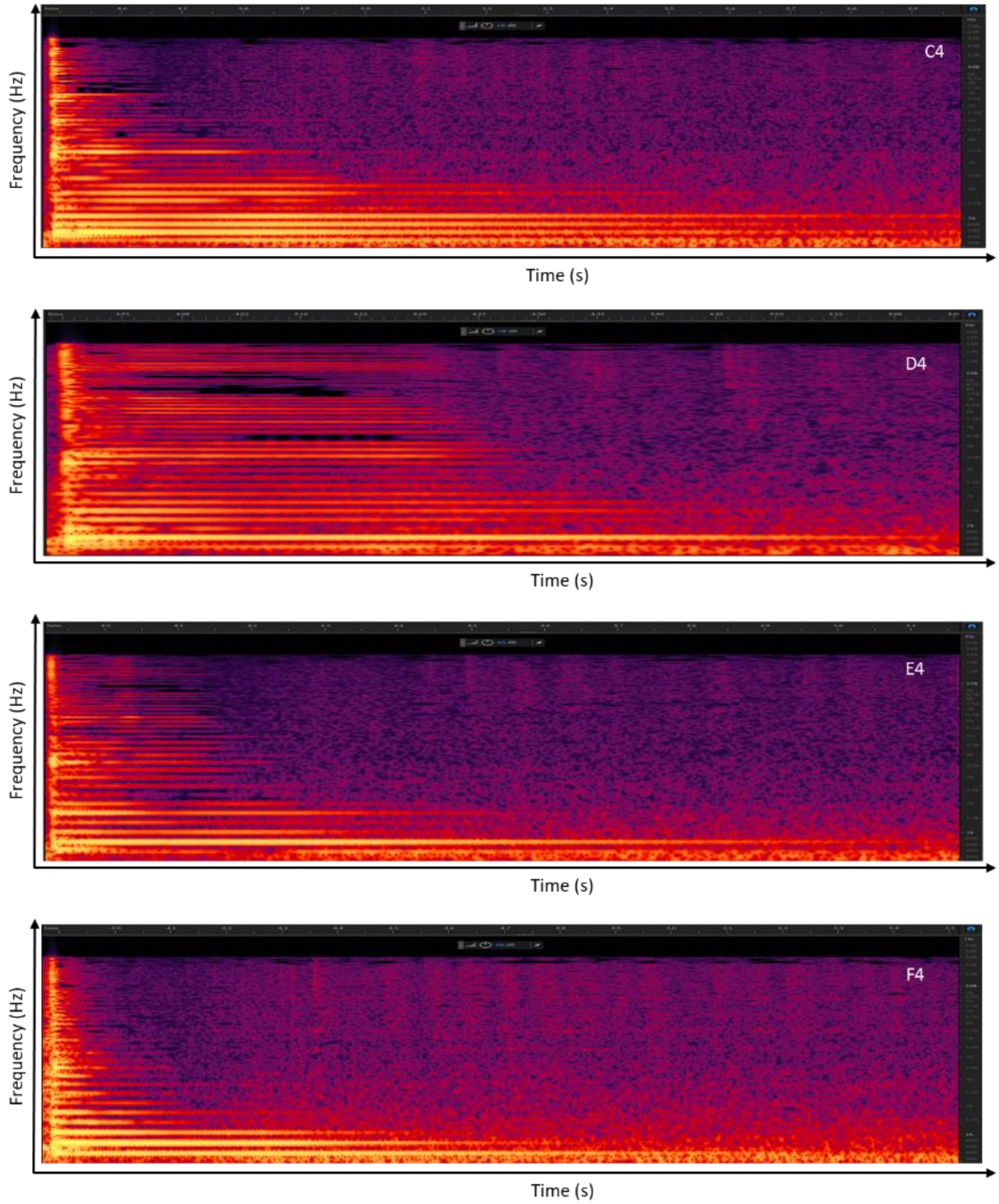


Fig. 12. The time frequency analysis (TFA) for 2nd string from adobe audition

This research contributes to the preservation of the instrument as a component of the intangible cultural heritage of the Batak Toba people of northern Sumatra, Indonesia. It provides an acoustic characterization of the hasapi, a plucked bowl-lute chordophone. The hasapi is essential to Batak Toba traditional music, especially in uning-uningan ensembles and ceremonial settings. As an instrument that possesses both musical and cultural significance, documenting its acoustic features is vital to ensure that its distinctive auditory qualities are preserved to time.

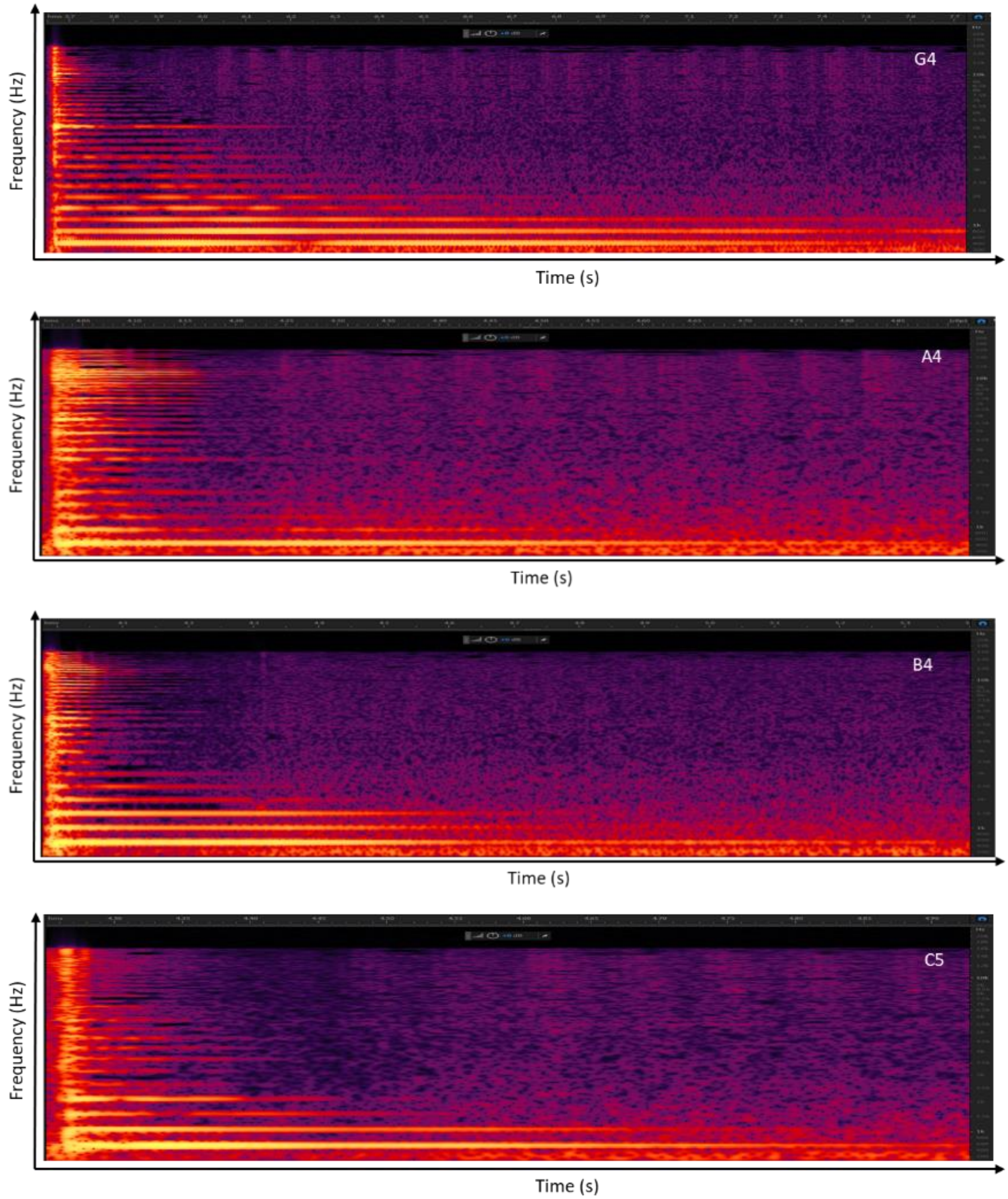


Fig.13. The TFA for 1st string from adobe audition

This study offers a thorough analysis of the hasapi's spectral and harmonic characteristics using the contemporary tools PicoScope and Adobe Audition. It also provides insightful information about how the instrument's construction – such as where the sound holes are located and the kind of wood used – affects its sound. By guaranteeing that the hasapi's physical and auditory qualities are maintained for present and future generations, this research contributes to sound preservation. Through an organized process of recording and describing its distinct harmonic structure, resonance, and timbre, this research offers a basis that may keep the instrument's acoustic history from being lost. The data from this study may also be incorporated into the plethora of contemporary applications created to support and promote traditional instruments, which would be advantageous to individuals tasked with maintaining and instructing these historically significant instruments. These traditional music-focused apps may aid in bridging the gap between contemporary technology and cultural heritage, giving younger generations fresh perspectives on the hasapi while also helping them understand its rich historical legacy.

CONCLUSIONS

1. The pitch and timbre of hasapi has been shown by PicoScope and Adobe Audition. Although the pitch and harmonics sound characteristics are similar, the higher pitch lacks the harmonics because the high frequency was absorbed by the wooden resonator.
2. The 2nd string (C4, D4, and E4) showed many partials except F4 with only 3 partials.
3. The 1st string (G4, A4, and B4) showed 4 and 5 partials except C5 with only 1 partial (only the fundamental frequency).
4. The distinctive feature of hasapi resonator used the sound hole at the back rather than at the front like it is on a guitar. The resonator shows less radiative effect whether with the microphone at the front or at the rear of the hasapi.
5. In addition, although both strings produced the harmonics frequency, the intensity of the partials in both strings display an irregular pattern, *i.e.*, a reduction of intensity (amplitudes of the integer overtones) is not proportional to increasing harmonic frequency in the string.
6. The timbre from Adobe Audition showed that the TFA are in accordance with the Picoscope spectra. Only TFA from C5 showed irregular pattern with the Picoscope output.

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