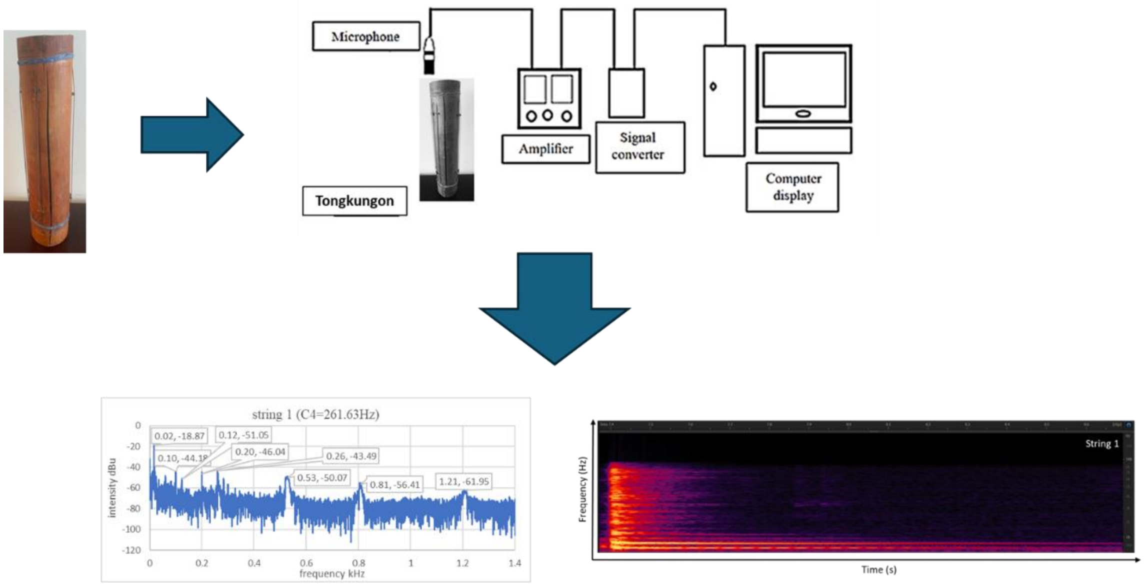
The Tongkungon: A Traditional KadazanDusun Plucked Musical Instrument from Sabah, Malaysia

Sinin Hamdan,[a,]* Khairul Anwar Mohamad Said,[a] Kuryati Kipli,[a] Ezra A. M. Duin,[b] and Aaliyawani E. Sinin [c]

* *Corresponding author: hsinin@unimas.my*

DOI: 10.15376/biores.20.1.357-367

GRAPHICAL ABSTRACT



The Tongkungon: A Traditional KadazanDusun Plucked Musical Instrument from Sabah, Malaysia

Sinin Hamdan,[a,]* Khairul Anwar Mohamad Said,[a] Kuryati Kipli,[a] Ezra A. M. Duin,[b] and Aaliyawani E. Sinin [c]

This study highlights the sound analyses in a studio settings for a KadazanDusun bamboo musical instrument from Sabah Malaysia called the tongkungon. The tongkungon is a type of chordophone built from betung bamboo trees, which are found growing close to rivers and also known as ‘poring’ in Sabah, Malayisa. It is also a plucked idiochordal bamboo tube zither. To adjust the pitches of the strings, the wedges can be shifted to shorten or lengthen them.The tongkungon sound radiator is made up of six strings with unique and innovative sound reproduction capabilities. Fast Fourier Transform (FFT) analysis was used to evaluate the frequency spectrum *via* a PicoScope oscilloscope. Adobe Audition was used to produce the time frequency analysis (TFA) spectrograms. The results showed the notes of the tongkungon strings 1, 2, 3 ,4, 5, and 6 to be C, E, B, A, F, and A, respectively. The tongkungon was tuned in the pentatonic scale F, A, B, C, and E. The 1st, 2nd, 3rd, 4th, 5th, and 6th strings were C4(261.63Hz), E4(329.63Hz), B3(246.94Hz), A3(220.00Hz), F3(174.61Hz), and A3(220.00Hz), respectively, *i.e*., with both 4th and 6th strings in A3. The frequency spectrum showed distinct fundamental and overtones frequencies. The first octave behaved as a multiple integer of the fundamental frequency for all strings. The number of partials in each string was inconsistent due to non-uniform thickness of the raised fibres from the bamboo tube.

DOI: 10.15376/biores.20.1.357-367

Keywords: Bamboo music instrument; Tongkungon; Fast Fourier transform; KadazanDusun

*Contact information: a: Faculty of Engineering, Universiti Malaysia Sarawak, 94300, Kota Samarahan, Sarawak, Malaysia; b: Faculty of Applied and Creative Art, Universiti Malaysia Sarawak, 94300, Kota Samarahan, Sarawak, Malaysia; c: Department of Science and Technology, Faculty of Humanities, Management and Science Universiti Putra Malaysia Bintulu Campus, 97008 Bintulu, Sarawak, Malaysia; * Corresponding author: hsinin@unimas.my*

INTRODUCTION

The development of traditional musical instruments used in Sabah is seen in terms of the quality and technique of making the instruments. The tongkungon is popular amongst the KadazanDusun people in Sabah, Malaysia (Pugh-Kitingan 2004). The instrument is handcrafted. One may differ from the others, such that the listed frequencies would vary from each other. The tongkungon has similairities in shape with other idiochordic instruments that are played in Sabah. This idiochordic instrument goes by several names depending on the tribe that plays it. For example, it is played by Satong (Kayan tribe) and Pek’Bu (Lun Bawang tribe) members. The respective versions are similar in structure even if they differ in size and tuning (Lim 2011). Since gongs vary in tuning depending on region and manufacturer, there may be variations in the intervals between pitches between versions of tongkungon and different makers of nominally the same version. Basically, every musical note and tuning depends on a set of aesthetic standards and customs within the community or musical ensemble. The tongkungon is utilized for individual amusement and relaxation, but it is also used to accompany dances or be performed as an ensemble at village festivals (Chong 2016). Tongkungon instruments are typically played alone to fill up time. Tongkungon music usually imitates the music of the gong ensemble. In the absence of a gong ensemble, these musical instruments are also played to accompany non-ritual dances performed in small groups (Matusky and Beng 2012).

Although this musical instrument is a solo instrument, it can sometimes be played in a duet (Matusky and Beng 2012). The strings of the tongkungon are tuned more or less to match the pitches of the community gong ensemble. The short rhythmic and melodic motifs that are repeated throughout the song show the iterative form in this music. Often the tongkungon is used to accompany the solo dance of “Magarang,” and even without a gong, this tongkungon will imitates the rhythm gong sound, but to play this musical instrument requires the finger skills of both hands (Matusky and Beng 2012). It is made from a large bamboo tube with its fibre string raised from the tube wall. The main characteristics that are important in making the tongkungon are the bamboo tube diameter, length between nodes, and thickness of the bamboo. The number and name of this string correspond to the main gongs (Scholz 2009). The quality and technique of making and developing of this traditional musical instrument is not recorded. Other instruments in Sabah are sompoton (Hamdan *et al.* 2022a), sundatang, and togunggak (bamboo gong). The togunggak is also known as tagunggak or togunggu. These instruments with their own roles are special within the community for certain occasions. The tone and tone colour of these instruments are rarely discussed. The sound quality of an instrument is crucial and can be assessed by examining how each sound contributes to the overall auditory experience. This study attempts to examine the tone and tone colour of the KadazanDusun tongkungon.

‘Poring’ bamboo (*Gigantochloa levis*-Gramineae) is commonly used for the manufacture of musical instruments due to the structure of bamboo (Wegst 2008). In Sabah, bamboo is widely used for musical instruments, but the knowledge and acoustic organology are lacking, which has resulted in less interest by researchers on bamboo musical instruments. For widespread acceptance and international reception of traditional bamboo musical instruments from Sabah, a comprehensive study of tone, tone colour, and sustain aspects becomes essential. However, it is known that these instruments are a favourite within the ethnomusicology community without requiring an exhaustive technical analysis. The instrument has garnered appreciation solely for its sound and musicality can be found in the web page:

https://www.auralarchipelago. com/auralarchipelago/talempong botuang

Motivations to study traditional instruments can often surpass strict analytical criteria, emphasizing the universal enjoyment of their unique sounds. Further research is needed to explore the technical and acoustic characteristics of the tube zithers tongkungon. Therefore, this research studies the harmonic and overtone spectrograms, which can serve as a guide for fabricating bamboo tongkungon.

Bamboo, the raw material used for making musical instruments was earlier used in percussion, wind, and stringed instruments (Wegst 2008). The bamboo pipe walls exhibit non-uniform density in the radial direction due to the layered structure of fibres. This makes the elastic moduli in the parallel distinct with the elastic moduli in the perpendicular direction to the bamboo fibres. The resonator in tongkungon musical instruments make use of the hollow form of bamboo. To the knowledge of the authors, the studies of bamboo for tongkungon musical instruments are not available. Previous works done by the author on traditional bamboo musical instruments were sompoton (Hamdan *et al*. 2022a), angklung (Hamdan *et al*. 2022b), and pratuokng (Hamdan *et al*. 2024). The audio recordings of tongkungon will add a necessary technical dimension to the sound elements. The sound production was evaluated *via* Picoscope oscilloscope and Adobe audition. The frequency retrieval was analysed *via* Fast Fourier Transform (FFT) to identify the fundamentals (pitch) and overtones of the individual strings. The sound was measured through studio recordings and scientific assessments of the music features in FFT. The primary aim of this study is to investigate the audio recordings from the strings and the instrument's ability for each string to reproduce sound.

In the Tambunan district, Sabah, Malaysia, this instrument is normally played solo to accompany ‘Magarang’ dancing when the Sopogandangan gong is not used. This is because Tongkungon can produce a music melody played by the gong set. To play and listen to the gong sound beating requires many players, whereas with the tongkungon, one player can produce the gong sound beating. The tongkungon has 2 sections, *i.e.*, strings and a resonator. When the string is plucked by the finger, vibration occurs, and it is amplified by the resonator. Part of the bamboo is split to let the sound echo become amplified. The tongkungon is made of a bamboo tube with the strings raised from the outer fibers of the tube. The support and peg are adjusted to tune according to the Sopogandangan gong.

EXPERIMENTAL

The material and acoustic organology of bamboo for making bamboo zither tongkungon are shown in Fig. 1. It is made from a piece of big poring bamboo (*Gigantocloa levis*) tube on average 60 cm long. The average height of poring bamboo is 20 m. This material also is used for light constructions and erosion control. The bamboo tree is of great beauty, with its erected culms and medium size. In general, this instrument has 4 to 8 strings, while an expert player can play the tongkungon with up to 15 strings. The tension of the string is adjusted by shifting the location of the supports/peg, which eventually tunes and determines their notes. The sound produced is innovative and unique. The strings are named based on gong’s name in Sopogandangan gong set, *i.e.*, bobogon, tagung tolombou, tagung tohison, kuribadon, kutou kutowon, tawag, and tongtongon (Matusky and Beng 2017).

Fig. 1. Front view, back view, left view with 2 strings, and right view with 4 strings

There are physically 6 strings made from the trunk of the bamboo tube. Two strings are on the left side and 4 strings are on the right side with the bamboo split at the front and back to make it function as a resonator. The strings are played by plucking with fingers on both sides of the bamboo. The supports/pegs to raise the strings are placed toward the end of the bamboo tube ends. The height and location of the peg determined the tension in the string.

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. 2. The placement of the tongkungon was strategically chosen to optimize sound collection while minimizing interference. Before the sounds are blasted out, an extending hole in the center of the tongkungon, facing the performer, amplifies their volume (Chong 2016). The tongkungon can be held vertically or leaned against the wall, then plucked by the player with his fingers. 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 were acquired by measurements conducted using the PicoScope. Following the capture and recording of the sound data, the FFT was analyzed using Adobe Audition 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.

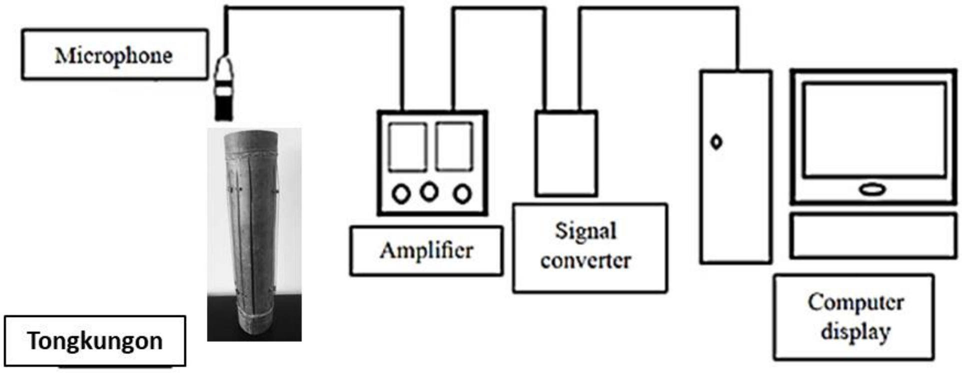
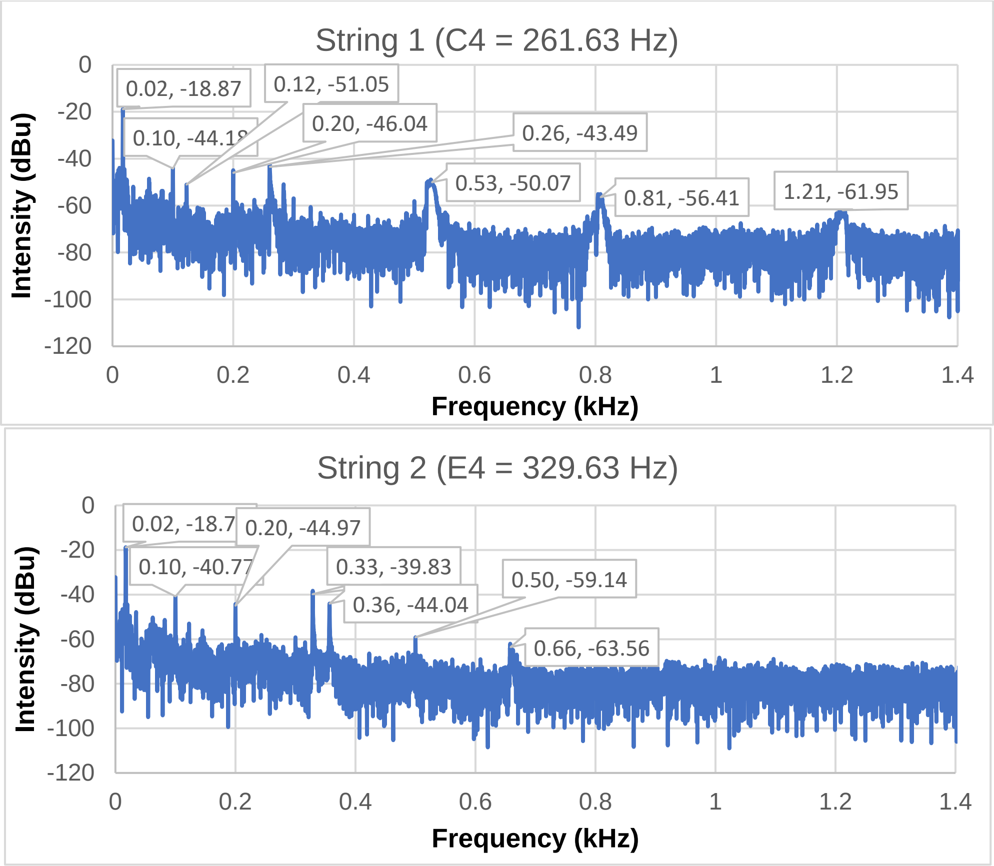


Fig. 2. Schematic diagram of experimental setup

RESULTS AND DISCUSSION

The fundamental sound is produced by vibrating the entire string length. It also can be referred to as a harmonic because it vibrates one times the fundamental frequency (Pierce 2001) and is also termed the first harmonic. If f_o is the fundamental frequency, then the first harmonic is 1xf_o, the second harmonic is 2xf_o, and the third harmonic is 3xf_o, *etc*. The harmonic is a set of positive integer multiples of the fundamental frequency. Figure 3 displays the fundamental and partial frequencies for strings 1 to 6.



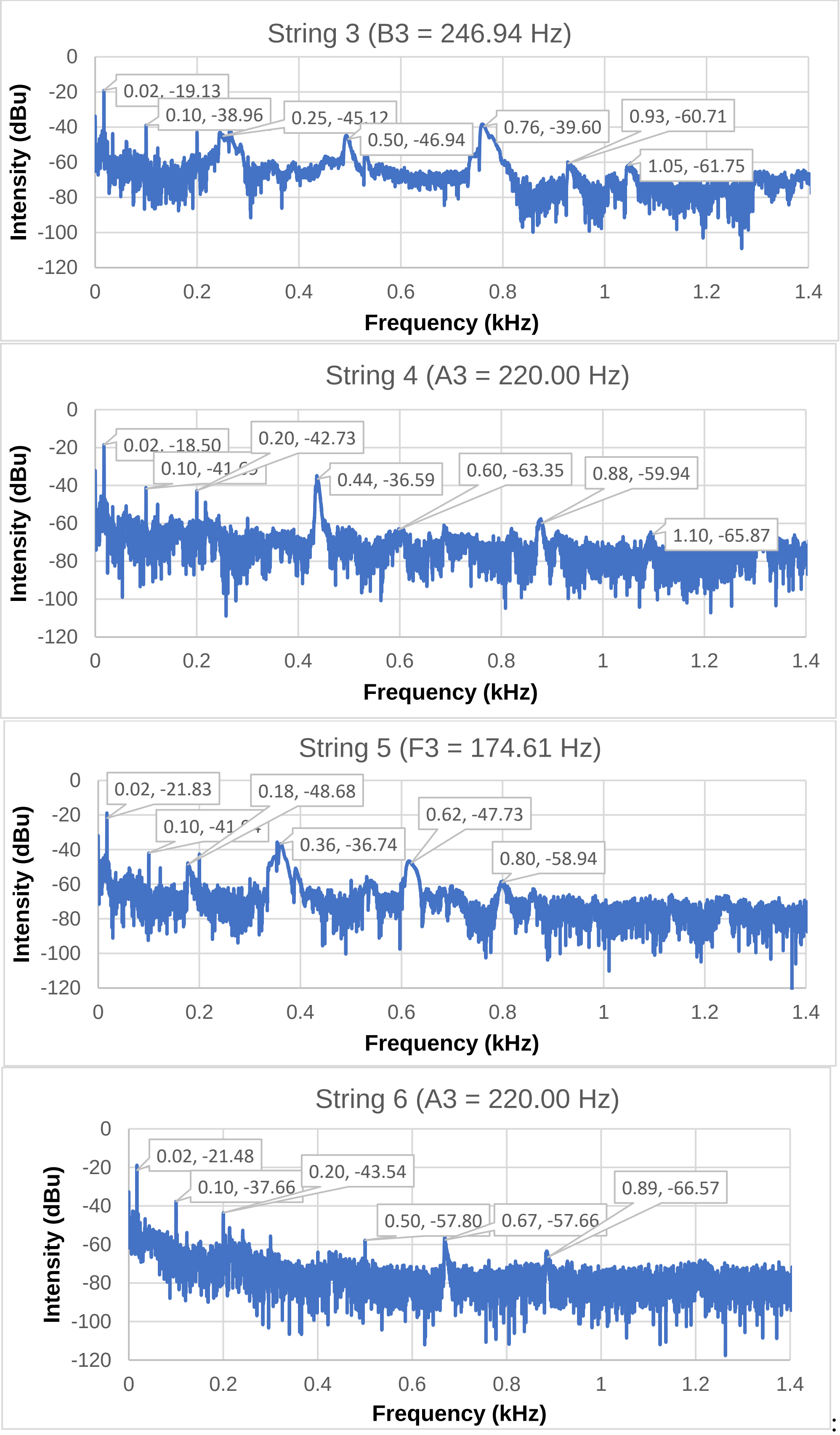


Fig. 3. The fundamental and partial frequencies for strings 1 to 6

For string 1 the fundamental frequency (C4=261.63 Hz) is at (0.26, -43.49) and the partial frequencies are at (0.53, -50.07), (0.81, -56.41), and (1.21, -61.95). For string 2 the fundamental frequency (E4=329.63Hz) is at (0.33, -39.83) and the partial frequencies are at (0.36, -44.04), (0.50, -59.14) and (0.66, -63.56). For string 3 the fundamental frequency (B3=246.94Hz) is at (0.25, -45.12) and the partial frequencies are at (0.50, -46.94), (0.76, -39.60), (0.93, -60.71), and (1.05, -61.75). For string 4, the fundamental frequency (A3=220.00Hz) is at (0.20, -42.73) and the partial frequencies are at (0.44, -36.59), (0.60, -63.65), (0.88, -59.54) and (1.10, -65.87). For string 5 the fundamental frequency (F3=174.61Hz) is at (0.18, -48.68) and the partial frequencies are at (0.36, -36.74), (0.62, -47.73) and (0.80, -58.94). For string 6 the fundamental frequency (A3=220.00Hz) is at (0.20, -43.45) and the partial frequencies are at (0.50, 57.80), (0.67, -57.66) and (0.89, -66.57).

The distinct fundamental frequency in string 1 at 260 Hz ~ C4 (261 Hz) showed 1 harmonic partial at one octave lower, *i.e.*, 120 Hz, only 1 harmonic partial at 530 Hz, and 4 non-harmonic partials at 100, 200, 810, and 1210 Hz. String 2 had the fundamental frequency at 330 Hz ~ E4 (329 Hz), 1 harmonic partial at 660 Hz, and several non-harmonic partials both below and above the fundamental frequency. String 3 had fundamental frequency at 250 Hz ~ B3 (246 Hz) and 3 harmonic partials at 500, 760, and 1050 Hz. String 4 had fundamental frequency at 200 Hz ~ A3 (220 Hz) and 3 harmonic partials at 440, 600, and 880 Hz. String 5 had fundamental frequency at 180 Hz ~ F3 (174 Hz) and 1 harmonic partial at 360 Hz. String 6 had fundamental at 200 Hz ~ A3 (220 Hz) and 2 harmonic partials at 670 and 890 Hz with 1 harmonic partial at one octave lower at 100 Hz. Strings 1 and 6 had lower harmonic partial as in string 5 of the pratuokng, which showed distinct fundamental frequency at 500 Hz with 1 harmonic partials at one octave lower at 250 Hz and only 3 non-harmonic partials (Hamdan *et al*. 2024).

The study of the frequency spectrum revealed that different individual strings of the tongkungon did not exhibit a comparable pattern. The higher partials exhibited inconsistent intensity compared to the fundamental frequency in several cases. Partials were observed in strings 1 and 6, which are positioned one octave below the fundamental frequency. This could be attributed to the irregular thickness of the bamboo fibers in the strings. The vibration capacity at the most usual octave is influenced by the mechanical qualities of bamboo fibers, specifically in relation to their length and tension during strumming. There will be variations in the vibrational characteristics between thicker and thinner fibers. The effect can also be influenced by the stiffness, damping, and mass distribution of the material. According to Aditanoyo *et al*. (2017), the utilization of thicker fibers in the bamboo tube zither results in a diverse range of sounds due to variations in intrinsic frequencies and harmonic qualities.

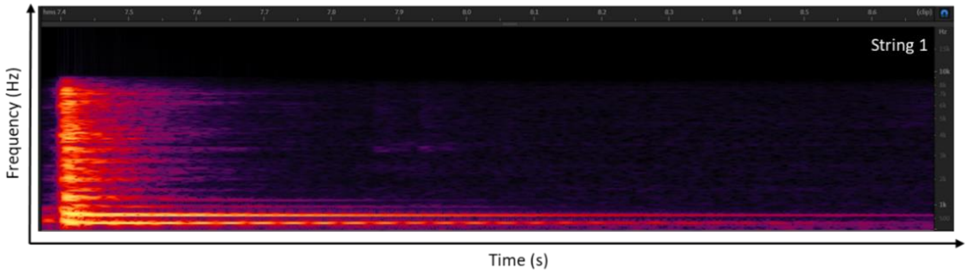
Table 1 displays the distinct fundamental frequency (in bold) and higher partial frequencies. In particular, the first octave was found to be almost a multiple integer of the fundamental frequency for all strings except string 6, with only 1 harmonic partial at one octave lower at 100 Hz. The inconsistent number of partials in each string can be attributed to the inconsistent thickness of the raised fibre from the bamboo tube.

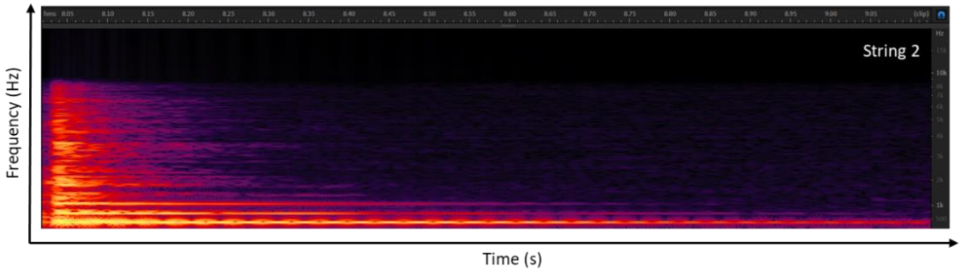
Table 1. Fundamental Frequency f_o (bold) and Partials Frequency for Strings 1 to 6

String No.	1st Peak	2nd Peak	3rd Peak	4th Peak	5th Peak	6th Peak	7th Peak	8th Peak	Pitches as Heard f_H	Difference Between f_H and f_o
1	20	100	120	200	**260**	530 ($2f_o$)	810	1200	C4 (261)	261 – 260 = 1
2	20	100	200	**330**	360	500	660 ($2f_o$)	-	E4 (329)	330 – 329 = 1
3	20	100	**250**	500 ($2f_o$)	760	930	1050	-	B3 (246)	250 – 246 = 4
4	20	100	**200**	440 ($2f_o$)	600	880	1100	-	A3 (220)	220 – 200 = 20
5	20	100	**180**	360 ($2f_o$)	620	800	-	-	F3 (174)	180 – 174 = 6
6	20	100 ($0.5f_o$)	**200**	500	670	890	-	-	A3 (220)	220 – 200 = 20

Frequency f_H is the Pitches as Heard

The fundamentals for the 1st, 2nd, 3rd, 4th, 5th, and 6th strings were 260 Hz (C4 = 261 Hz), 330 Hz (E4 = 329 Hz), 250 Hz (B3 = 246 Hz), 200 Hz (A3 = 220 Hz), 180 Hz (F3 = 174 Hz), and 200 Hz (A3 = 220 Hz). The instrument produces C, E, B, A, F and A notes. Typically, the specific adjustments differ based on geographical areas. With the exception of string 6, all strings exhibited the initial octave, denoted as $f1 = 2fo$. The variability in the quantity of partials observed in each string was ascribed to the inadequate thickness of the elevated fiber derived from the bamboo tube. The tongkungon was tuned in the pentatonic scale F, A, B, C, and E. The standard interval between strings was TSST, which stands for F3 to A3 sound as tone (T), A3 to B3 to C4 sound as semitone (S), and C4 to E4 sound as tone (T).





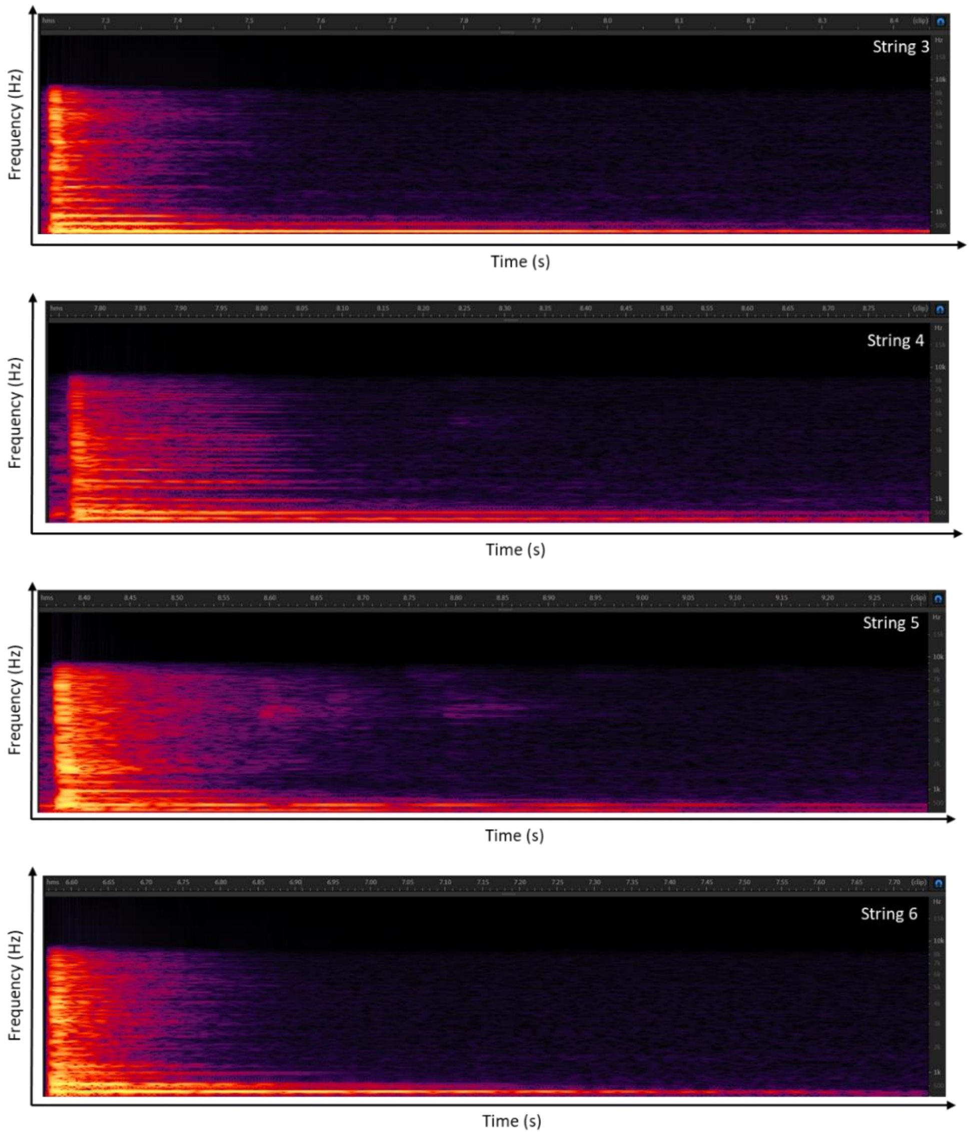


Fig. 4. The time frequency analysis (TFA) for the six strings from Adobe

The measured ratios influence the overall sound and personality of each performance, considering any potential musical repercussions. Complex ratios sometimes result in dissonance, whereas simple ratios often generate consonant sounds. This study also promotes the exploration of patterns or unique characteristics in pitch ratios that could potentially influence the perception of scales or enharmonic relationships. This comparison analysis elucidates the harmonic nuances present, emphasizing both shared qualities and unique tone profiles of each bamboo tube zither.

The time frequency analysis (TFA) for the six strings from Adobe Audition is depicted in Fig. 4. String 4 exhibited the most vibrant hue, with strings 2 and 5 following suit. The fundamental frequencies of strings exhibited notable distinctions. Variations arose in the unique tones emitted by each string. The disparity in sustaining of the sound detected among the different strings located on the bamboo tube zither indicated that the tone of string 1 exhibited a shorter duration in comparison to the sustained output of the remaining strings. The variation in sustain highlights the comparable autonomy of the string's vibrational output. Practically speaking, because string 2 had a shorter sustain means that its sound decayed more quickly after being plucking. This created a noticeable difference between the longer-lasting tones of the string 3 and the swiftly decreasing tonalities of the other string. The distinctive and distinguishable features of each component are enhanced by this characteristic, highlighting the individual contributions of all the strings to the overall acoustic profile of the bamboo tube zither.

The endeavor to ascertain the tonal characteristics and timbre of the bamboo zithers employed by the KadazanDusun community represents an endeavor to preserve the distinct vocalizations and auditory expressions of many societies, thereby mitigating the risk of their gradual alteration or extinction. As younger generations increasingly embrace mainstream cultural activities, numerous indigenous languages and musical traditions face the imminent threat of extinction. By extracting these tones, sounds, and musical traditions, the goal is to contribute to the preservation of these elements for the sake of study and appreciation by future generations. Furthermore, apart from the preservation of cultural legacy, this study has the potential to foster enhanced comprehension and admiration for a wide range of viewpoints. Through immersing oneself in the auditory and vocal aspects of various cultures, one can cultivate a more profound admiration for the abundance and variety of human encounters. This, in turn, facilitates a more comprehensive understanding of how sound influences our perception of the surrounding world.

CONCLUSIONS

1. The fundamentals for the 1st, 2nd, 3rd, 4th, 5th, and 6th strings were 260 Hz (C4 = 261 Hz), 330 Hz (E4 = 329 Hz), 250 Hz (B3 = 246 Hz), 200 Hz (A3 = 220 Hz), 180 Hz (F3 = 174 Hz), and 200 Hz (A3 = 220 Hz).
2. The instrument was able to produce C, E, B, A, F, and A notes, and was tuned in the pentatonic scale F, A, B, C, and E. All strings (except string 6) displayed the first octave (*i.e.*, $f_1 = 2f_0$).
3. The signals in the frequency spectrum showed both distinct fundamental notes and had different number of higher partial frequencies; in particular, the first overtones were present in all strings except string 6 with one octave lower.
4. The inconsistent number of partials in each string was attributed to the inconsistent thickness of the raised fiber from the bamboo tube.

ACKNOWLEDGMENTS

The authors are grateful to Universiti Malaysia Sarawak for providing the technical and financial assistants. The authors would like to thank Mr. Kuhim@Ebin Ugat from Tamparuli Training Centre, Sabah, Malaysia for all the support provided in the smooth conduct of this research.

REFERENCES CITED

Aditanoyo, T., Prasetiyo, I., and Putra, I. B. A. (2017). "Study on vibro-acoustics characteristics of bamboo-based violin," *Proc. Eng.* 170, 286-292. DOI: 10.1016/j.proeng.2017.03. 029

Chong, L. S. (2016). "Surviving traditional music instruments of Dusun Tindal within its modern community in Kampun Tinuhan," *Int. J. of Creat. Future and Heritage* 4(2), 63-84. DOI: 10.47252/teniat.v4i2.344

Hamdan, S., Rahman, M. R., Mohamad Said, K. A., Zainal Abidin, A. S., and Musib, A. F. (2022a). "Sompoton: Sabah bamboo mouth organ," *BioResources* 17(3), 5335-5348. DOI: 10.15376/biores.17.3.5335-5348

Hamdan, S., Rahman, M. R., Zainal Abidin, A. S., and Musib, A. F. (2022b). "Study on vibro-acoustic characteristics of bamboo-based angklung instrument," *BioResources* 17(1), 1670-1679. DOI: 10.15376/biores.17.1.1670-1679

Hamdan, S., Mohamad Said, K. A., Faudzi Musib, A., Rahman, M. R., Sawawi, M., and Sinin, A. E. (2024). "Pratuokng: The Borneo bamboo zither of Bidayuh Sarawak," *BioResources* 19(1), 1305-1315. DOI: 10.15376/biores.19.1.1305-1315

Lim, C. K. N. (2011). "The Pek Bu played by the Lun Bawang, Its performance and music," *The Sarawak Museum J.* LXVIII(89), 41-52.

Matusky, P., and Beng, T. S. (2012). *Muzik Malaysia: Tradisi, klasik rakyat dan sinkretik*, P. Matusky & T. S. Beng (eds.), UM Press, Kuala Lumpur, Malaysia.

Matusky, P., and Beng, T. S. (2017). *The Music of Malaysia: The Classical, Folk and Syncretic Traditions*, Routledge, London, UK. DOI: 10.4324/9781315223025

Pierce, J. R. (2001). *Consonance and Scales. Music, Cognition, and Computerized Sound – An Introduction to Psychoacoustics*, P. R. Cook (ed.), MIT Press, Cambridge, MA.

Pugh-Kitingan, J. (2004). *Selected Papers on Music in Sabah*, Master's Thesis, University Malaysia, Sabah, Kota Kinabalu, Malaysia.

Scholz, H. (2009). "Music instruments in Sabah: Sabah's musical heritage and future," (https://www.flyingdusun.com/004_Features/043_instruments.html), Accessed 15 April 2024.

Wegst, U. G. K. (2008). "Bamboo and wood in musical instruments," *Ann. Rev. of Mat. Res.* 38, 323-349. DOI: 10.1146/annurev.matsci.38.060407.132459

Article submitted: April 23, 2024; Peer review completed: May 25, 2024; Revised version received: May 28, 2024; Accepted: October 21, 2024; Published: November 14, 2024.
DOI: 10.15376/biores.20.1.357-367