The Sound of the 'Kiruncong' (Bidayuh Bamboo Music Instrument)

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The kiruncong is a traditional bamboo idiophone of the Bidayuh community in Sarawak, Malaysia, whose acoustic characteristics have received limited scientific investigation. This study examined the frequency spectra, pitch characteristics, and rhythmic function of a single Kiruncong instrument set using Fast Fourier Transform (FFT) and time-frequency analysis (TFA). The six bamboo tubes produced fundamental frequencies of 199, 396, 391, 408, 463, and 507 Hz, corresponding approximately to G3, G4, G4, A♭4, B♭4, and B4. For Tubes 2 to 6, the measured fundamental frequencies were consistent with the perceived pitches. However, Tube 1 exhibited an anomalous pitch perception, with listeners identifying C4 despite a measured fundamental of G3. Since the measured partials did not form the harmonic series required for the classical missing fundamental phenomenon, the perceived pitch is likely influenced by psychoacoustic factors such as inharmonic partials, resonance, transient characteristics, and spectral properties. The results show that the Kiruncong produces complex inharmonic spectra in which the fundamental frequency, partials, dominant spectral peaks, and perceived pitch are distinct acoustic attributes. Rhythmic analysis also revealed interlocking performance patterns characteristic of Southeast Asian traditional music. These findings provide baseline acoustic data that support future ethnomusicological research and the preservation of Bidayuh musical heritage.

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INTRODUCTION

Traditional musical instruments are important cultural expressions that reflect the identities, histories, and artistic traditions of Malaysia's diverse ethnic communities (Nasuruddin 2007; Yousof 2013). Malaysian society's diversity has led to a variety of inventive approaches to the creation and use of musical instruments. According to their cultural heritage, every ethnic group in Malaysia has its own traditional musical instruments. Previous ethnomusicological studies have shown that traditional musical instruments in many Malaysian indigenous communities served not only for entertainment but also in ceremonial rituals, social communication, and expressions of cultural identity (Ahmad 1994; Nasuruddin 2007). Many indigenous communities in Malaysia, including those in Sabah and Sarawak, traditionally have used locally available materials such as bamboo, wood, and gourds in the construction of musical instruments (Ahmad 1994; Yousof 2013).

For instance, the keluri (Ahmad 1994) is composed of organized bamboo tubes and dried gourd. In the past, local natural resources, especially plants, were used by communities to make musical instruments. The extensive use of bamboo, wood, and gourds reflects the close relationship between indigenous communities and their natural environment, a characteristic discussed in previous studies of Malaysian traditional material culture (Yousof 2013). The sompoton (Hamdan *et al*. 2022b) is a musical instrument composed of bamboo tubes and dried gourd. It is regarded as an eco-friendly instrument that prioritizes integration and harmony in its manufacturing process. According to Said (2004), instruments in which bamboo is struck by the player are among the musical instruments used in folk songs that are typically made from natural materials. Malaysian musical instruments were divided into a number of categories by Nasuruddin (2007). The serunai, seruling, kesuling, selumpit, turali, silinguit, sompoton, and keluri belong to the aerophones group. Another traditional musical instrument found in Malaysia, such as the angklung (Hamdan *et al*. 2022a) and sompoton (Hamdan *et al*. 2022b), have been studied by the authors.

The Bidayuh Kiruncong has not received much attention in the scientific literature, despite the fact that many Malaysian traditional musical instruments have been documented from both cultural and acoustical perspectives. The majority of current understanding is restricted to its cultural significance; objective assessments of its frequency spectrum, harmonic behavior, pitch characteristics, and acoustic features are inadequate. As a result, this native bamboo instrument cannot be systematically documented, compared, or preserved due to the lack of a baseline acoustic dataset. In order to fill this gap, each Kiruncong tube’s frequencies, harmonic content, and musical notes were characterized using Fast Fourier Transform (FFT) analysis. By combining contemporary acoustic signal analysis with ethnomusicological documentation, the study offers the first scientific acoustic characterization of the Kiruncong and establishes reference data for further study and cultural heritage preservation.

Research gap and novelty

Despite the Bidayuh Kiruncong's cultural significance and declining use, no prior study has used contemporary signal analysis to properly characterize the acoustic qualities (fundamental frequencies, harmonics, and pitch). By combining ethnomusicological documentation of the Kiruncong with FFT-based acoustic analysis, this work is the first to produce baseline frequency and harmonic data that help scientific inquiry as well as the preservation of Bidayuh intangible cultural heritage.

Context

The Bidayuh community possesses a rich cultural heritage that has been preserved through generations, with traditional music serving as an important expression of its cultural identity, social values, and ceremonial practices. In Serian, Sarawak, Malaysia, the Kiruncong is recognized as one of the traditional bamboo musical instruments of the Bidayuh people. It is commonly played during cultural events, particularly the Gawai harvest festival, and reflects the creativity and craftsmanship of earlier generations alongside other traditional instruments such as the gong, canang, and drum. Existing knowledge of the Kiruncong is largely limited to its cultural significance, traditional usage, and role in community performances. However, despite its importance as an element of Bidayuh intangible cultural heritage, there is little scientific documentation of its acoustic characteristics, including its frequency, pitch, harmonic structure, and musical properties. Consequently, no baseline acoustic data are available to support future research, preservation, or comparison with other indigenous bamboo instruments. Field observations and interviews conducted during this study indicate that the number of active Kiruncong players has declined, particularly among younger members of the Bidayuh community. As a result, traditional knowledge related to the construction, performance, and acoustic characteristics of the Kiruncong is at risk of being lost. To address these gaps, this study provides the first objective acoustic characterization of the Kiruncong by identifying the fundamental frequencies, corresponding musical pitches, and harmonic components of each bamboo tube using Fast Fourier Transform (FFT) analysis. In addition, the study documents the instrument's rhythmic and musical structure within its traditional performance context. By integrating scientific acoustic analysis with ethnomusicological documentation, this research establishes baseline acoustic data for the Kiruncong, contributes new knowledge to the study of indigenous bamboo musical instruments, and supports ongoing efforts to preserve and promote the musical heritage of the Bidayuh community.

Bidayuh music is an important expression of the cultural identity of the Bidayuh communities of Sarawak. Traditionally, music accompanies agricultural activities, communal celebrations, healing rituals, courtship, and festivals such as the Gawai harvest celebration. Musical performances reinforce social cohesion, transmit oral traditions, and preserve indigenous knowledge across generations. Characteristics of traditional Bidayuh music include: strong links between music and community rituals; vocal songs accompanied by bamboo and percussion instruments; and music that varies among the different Bidayuh groups (Biatah, Bukar-Sadong, Jagoi, Selako-Lara, and others). Performance practices are based largely on oral transmission rather than written notation.

Bamboo is the principal material used in many traditional Bidayuh instruments because it is readily available, lightweight, and produces distinctive timbres. The examples include Kiruncong – a bamboo idiophone unique to the Bukar-Sadong Bidayuh of Serian and Pratuokng (Hamdan *et al.* 2024) – an idiochord bamboo tube zither used among the Biatah Bidayuh, bamboo flutes, bamboo percussion tubes, and bamboo stamping and rhythmic instruments used during dances and ceremonies. These instruments demonstrate the close relationship between the Bidayuh people and their natural environment while reflecting indigenous craftsmanship and musical knowledge. The Kiruncong is more than a musical instrument; it is part of the cultural heritage of the Bukar-Sadong Bidayuh. Previous studies describe several cultural functions, entertainment during community gatherings; accompaniment for traditional dances; performance during festivals and celebrations; strengthening social interaction among villagers; preserving Bidayuh identity and traditional knowledge; symbolizing local craftsmanship through bamboo instrument making. However, the instrument is becoming increasingly rare because fewer young people learn to play it, modernization has reduced its everyday use, traditional instrument makers are declining, and contemporary entertainment has replaced many traditional performances. The published research on the Kiruncong is relatively limited. The undergraduate study Kirunchong as a traditional musical instrument of the Bidayuh Serian community, Sarawak focused on: the historical background of the Kiruncong, its cultural and social functions, aesthetic values, factors contributing to its decline, and the importance of preserving the instrument (Aput 2014). Ng's comprehensive study of Bidayuh musical styles discusses Bidayuh musical traditions, musical instruments, performance contexts, relationships between music and Bidayuh society. Although the Kiruncong is mentioned as part of the Bukar-Sadong musical tradition, the emphasis is ethnomusico-logical rather than acoustical (Ng 2002)

A major research gap is that existing studies primarily describe the Kiruncong from historical, cultural, and ethnomusicological perspectives**,** with little or no quantitative analysis of its sound. Acoustic analysis would provide objective scientific data that complement traditional ethnographic work by examining: fundamental frequency (pitch), harmonic structure, overtone distribution, resonance characteristics, spectral content, temporal envelope, decay time, timbre, and sound pressure characteristics. Such measurements can answer questions that descriptive studies cannot, including: why does the Kiruncong produce its characteristic sound? How does bamboo construction influence resonance? How consistent are the pitches across different instruments? How does the instrument compare acoustically with other Bidayuh bamboo instruments? Can its acoustic properties be documented for digital preservation? The value of this approach is demonstrated by recent work on the Bidayuh Pratuokng**,** where researchers used FFT and time-frequency analysis (TFA**)** to identify note frequencies, harmonics, and spectral characteristics. That study shows how scientific acoustic methods can document indigenous instruments in ways that support preservation, comparison, and future instrument reconstruction. Existing research on the Kiruncong has concentrated on its history, cultural significance, aesthetic value, and preservation. However, there is a lack of systematic acoustic analysis examining its physical sound characteristics, including frequency spectrum, harmonic content, resonance, and timbre. Conducting acoustic analysis would provide objective scientific documentation of the instrument, complement ethnomusicological studies, support cultural preservation, and establish a reference for future research on Bidayuh bamboo musical instruments.

EXPERIMENTAL

The Kiruncong used in this study is a traditional Bidayuh bamboo idiophone made from *Gigantochloa levis* bamboo (Fig. 1).

Fig. 1. The *Gigantochloa levis* bamboo

This bamboo species is widely distributed in Malaysia and Southeast Asia and is commonly used for the manufacture of traditional musical instruments because of its thick culm walls, high density, good resonance, and resistance to cracking (Osman *et al*. 2022). The mechanical properties of G. levis, including its high modulus of elasticity and modulus of rupture, contribute to its suitability for producing stable acoustic vibrations. The Kiruncong set consisted of six bamboo tubes designated as M1, M2, B1, B2, A1, and A2 (Fig. 2). Tubes M1 and M2 measured 43 cm and 45 cm in length, respectively, with a diameter of 5.5 cm and a wall thickness of approximately 5 mm. Tubes B1 and B2 measured 40 cm and 44 cm in length, respectively, with a diameter of 6.5 cm and the same wall thickness, whereas tubes A1 and A2 both measured 35.5 cm in length with a diameter of 5.0 cm and a wall thickness of approximately 5 mm. The instrument was handcrafted by a traditional Bidayuh maker using conventional fabrication techniques and was in good playing condition throughout the experiment.

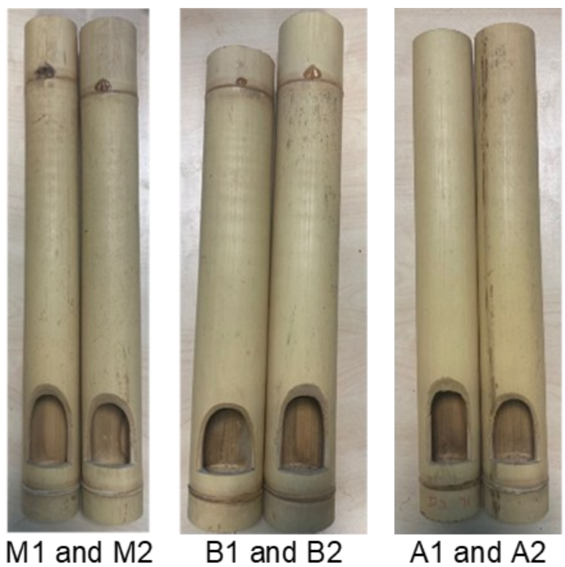


Fig. 2. The Kiruncong set M1 and M2; B1 and B2; and A1 and A2 bamboo tubes

Acoustic measurements were conducted in an anechoic chamber to eliminate environmental noise and sound reflections. All recordings were performed at room temperature (approximately 25 °C), where the speed of sound was assumed to be approximately 343 ms^{-1}. The Kiruncong was played in the conventional seated position by an experienced Bidayuh musician to replicate authentic performance practice. Each bamboo tube was struck individually at its designated striking point using the performer's customary playing technique. The same performer completed all recordings to minimize inter-player variability. Prior to data acquisition, the performer rehearsed the striking sequence several times to ensure consistent striking position and force. Each tube was recorded ten consecutive times under identical experimental conditions, and the microphone position, striking location, recording gain, and instrument orientation were maintained throughout the experiment. The recorded signals from the repeated trials were averaged to reduce random variability and improve measurement reliability. A condenser microphone Behringer C-2 with Behringer ultra-compact phantom power supply PS400 was positioned 20 cm directly in front of the instrument and aligned with the center of the vibrating bamboo tube. The microphone output was amplified using a Behringer Powerplay Pro XL amplifier (Zhongshan, Guangdong, China) before being connected to a

PicoScope 3000 Series oscilloscope and data acquisition system (Pico Technology, Eaton Socon, UK). The complete experimental arrangement is shown in Fig. 3.

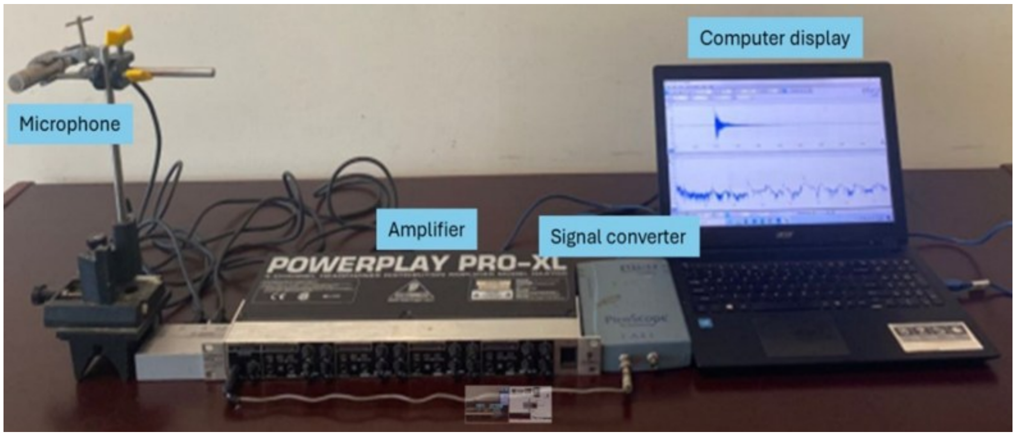


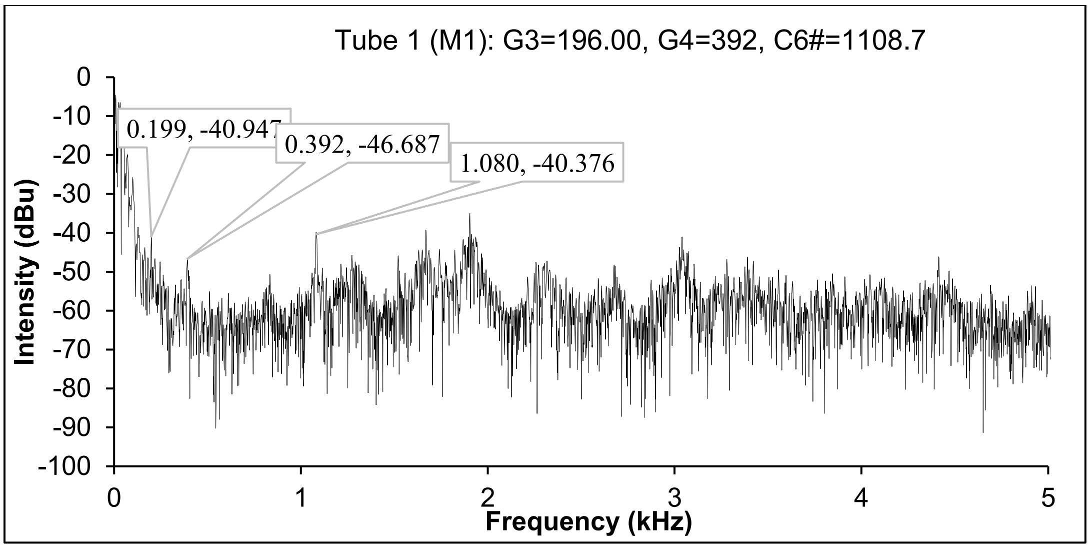
Fig. 3. The apparatus used in the experimental setup

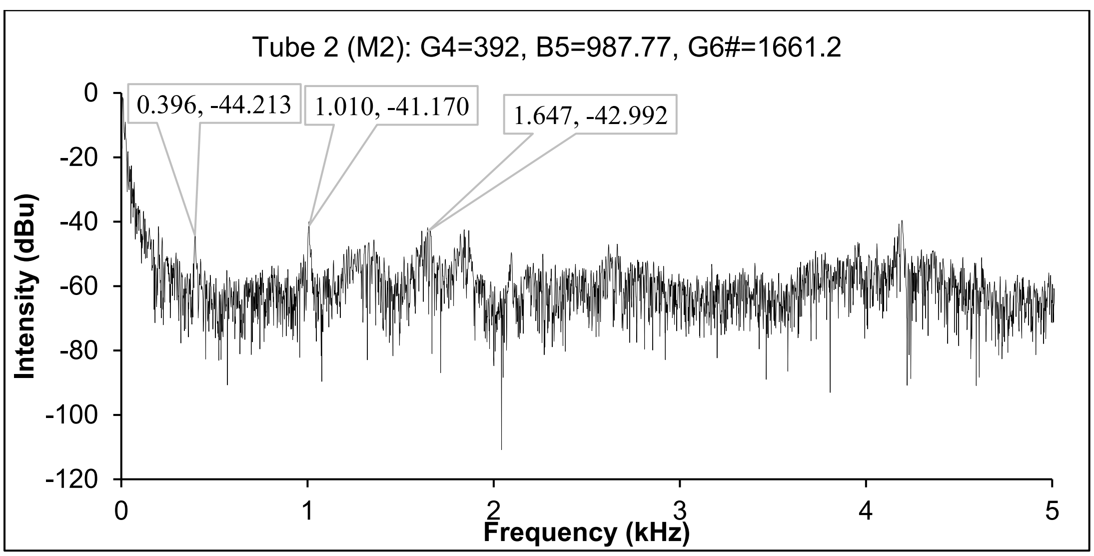
The acoustic signals were recorded in monophonic format with a sampling frequency of 48 kHz and a 24-bit resolution. Data acquisition and waveform visualization were performed using PicoScope software, which provided voltage-triggered recording, real-time waveform display, and spectral analysis. The recorded signals were exported to Adobe Audition for further processing. Prior to frequency analysis, each waveform was inspected to remove unwanted background noise and clipped sections. Fast Fourier Transform (FFT) analysis was then applied using a Hann window with a window length of 4096 samples. When measuring a vibration signal with PicoScope, for the frequency span between 0 to 100,000 Hz and spectrum bins selected as 131,072 bins; Δf = 100,000 Hz/131,072bins approximately 0.763 Hz. The theoretical bin width is 0.763 Hz. For a standard Hann window, the effective resolution bandwidth (RBW) becomes approximately 1.50 x 0.763 Hz = 1.144 Hz. This means that any two frequencies closer than approximately 1.144 Hz apart will blur together into a single peak. The fundamental frequency (f_0) of each tube was determined from the highest-amplitude spectral peak in the low-frequency region of the FFT spectrum. Subsequent prominent peaks were identified as partial frequencies (f_1 and f_2) to examine the harmonic characteristics of the instrument. The measured frequencies were then compared with the equal-tempered musical scale to determine the closest corresponding musical notes.

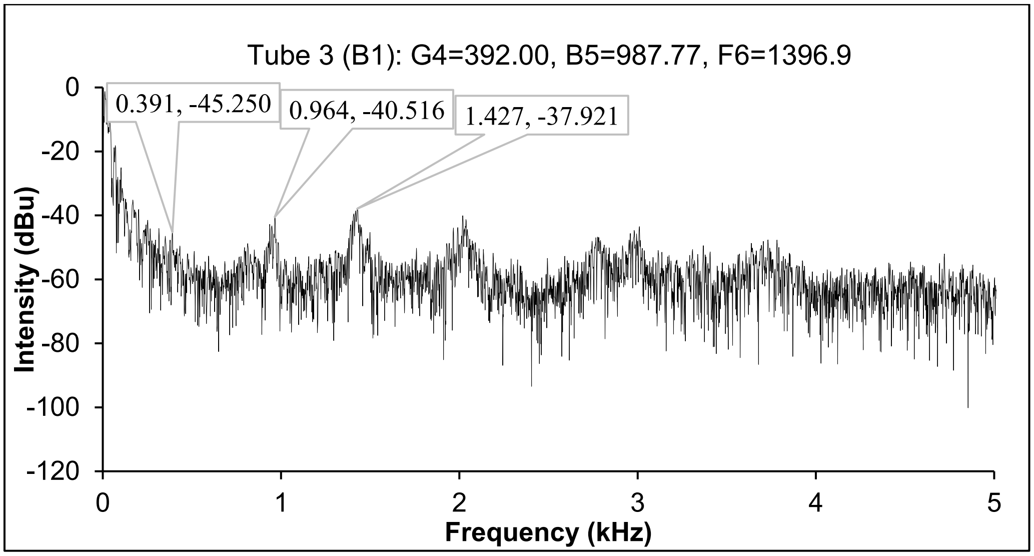
To ensure repeatability and reduce experimental error, all measurements were conducted using identical recording parameters, microphone placement, instrument orientation, and playing technique. Ten repeated recordings were obtained for each bamboo tube, and the resulting frequency spectra were averaged before analysis. Using a single experienced performer, fixed recording geometry, and identical signal-processing parameters minimized variability associated with human performance and measurement conditions, thereby providing reliable and reproducible acoustic data for comparison among the six Kiruncong tubes. Each bamboo tube was recorded ten times under identical experimental conditions. The same experienced musician performed all recordings using a consistent striking position and technique to minimize variability. For every recording, the microphone position, sampling rate, gain setting, and recording distance were kept constant. The acquired signals were processed using Fast Fourier Transform (FFT) with a Hann window and a 4096-point spectrum. The dominant spectral peak was identified as the fundamental frequency, while subsequent peaks were classified as partial frequencies. The frequency obtained from each trial was averaged, and the mean value was used for subsequent analysis. Repeated measurements ensured the reliability and repeatability of the acoustic data while minimizing random measurement errors.

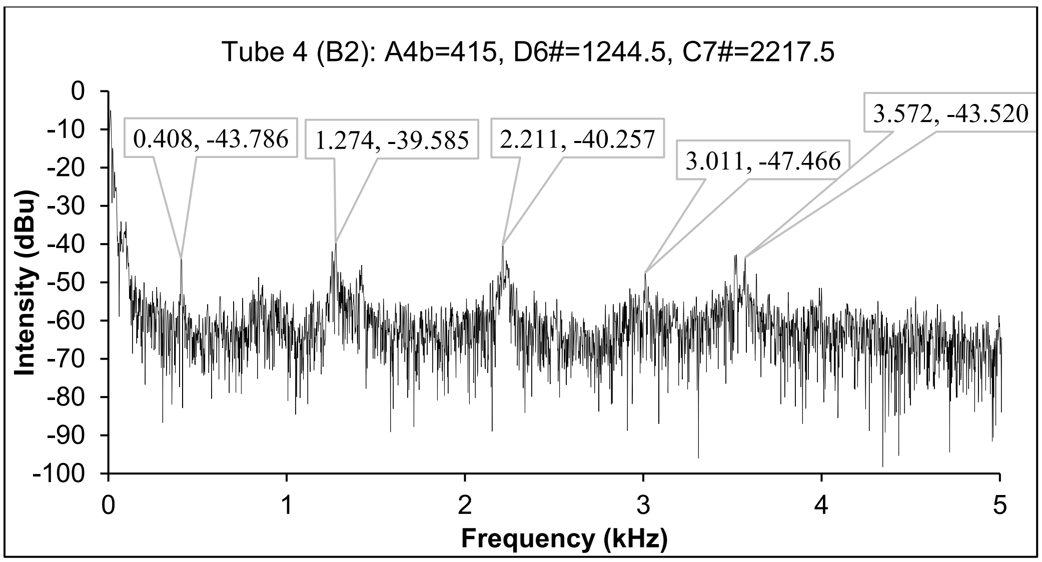
RESULTS AND DISCUSSION

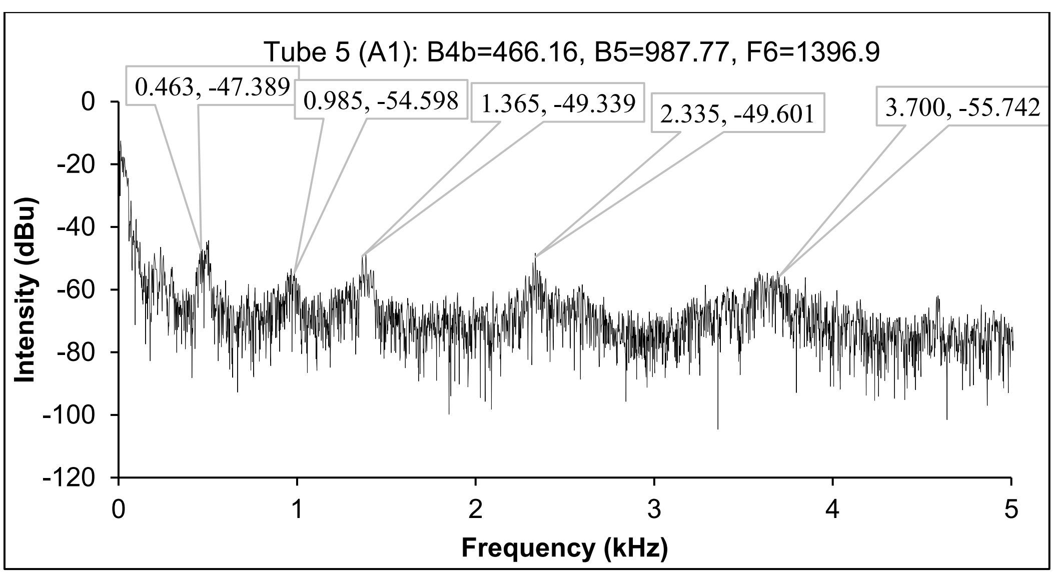
Figure 4 shows the frequency spectra of tubes 1(M1), 2(M2), 3(B1), 4(B2), 5(A1), and 6(A2).






Tube 3 (B1): G4=392.00, B5=987.77, F6=1396.9
0.391, -45.250
0.964, -40.516
1.427, -37.921
Intensity (dBu)
Frequency (kHz)


Tube 4 (B2): A4b=415, D6#=1244.5, C7#=2217.5
0.408, -43.786
1.274, -39.585
2.211, -40.257
3.011, -47.466
3.572, -43.520
Intensity (dBu)
Frequency (kHz)


Tube 5 (A1): B4b=466.16, B5=987.77, F6=1396.9
0.463, -47.389
0.985, -54.598
1.365, -49.339
2.335, -49.601
3.700, -55.742
Intensity (dBu)
Frequency (kHz)

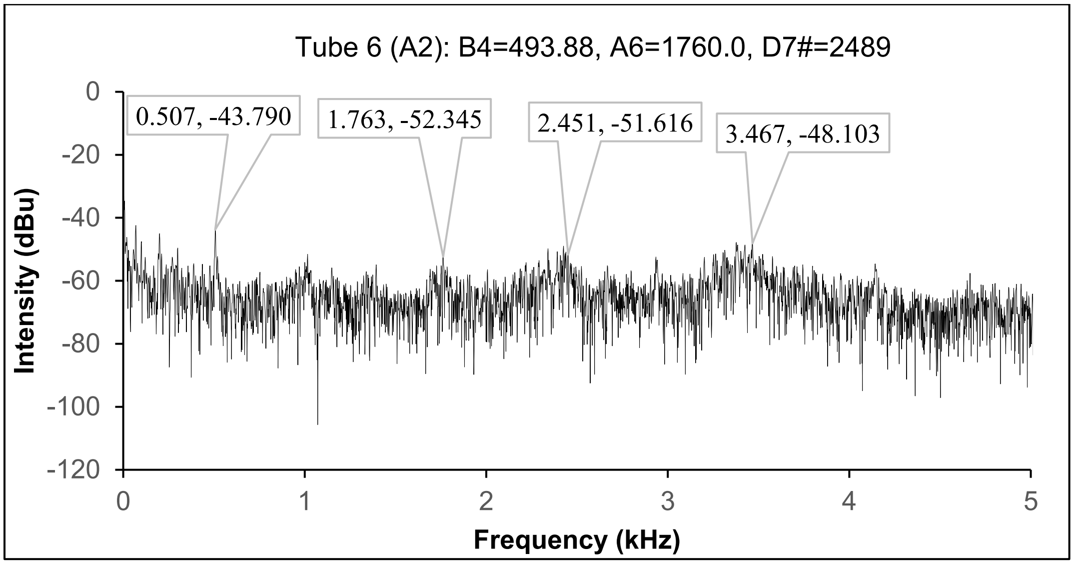


Fig. 4. FFT spectra of tubes 1, 2, 3, 4, 5 and 6

The frequency of tube 1, 2, 3, 4, 5 and 6 were 199, 396, 391, 408, 463, and 507 Hz, respectively with the corresponding notes G3 (196.00), G4 (392.00), G4 (392.00), A4b (415.30), B4b (466.16), and B4 (493.88), respectively. The tubes were not calibrated to a fixed musical pitch during the fabrication, and therefore their acoustic outputs reflect natural resonant properties rather than standardized tuning. The final pitch selection of the Kiruncong instrument was determined by the luthier, based on what is musically acceptable within the traditional melodic framework. Table 1 shows the fundamental frequency f0 and partial frequency f1 and f2 with the note of sound perception based on the piano scale.

Table 1. The Fundamental Frequency f_0 and Partial Frequency f_1 and f_2 with the Note of Sound Perception based on the Piano Scale

Tube	f0 (Musical Note)	f1 (Musical Note)	f2 (Musical Note)	Perception
1 (M1)	199 (G3=196)	392 (G4=392)	1080 (C6#=1108.7)	C4
2 (M2)	396 (G4=392)	1010 (B5=987.7)	1647 (G6#=1661.2)	G4
3 (B1)	391 (G4=392)	964 (B5=987.7)	1427 (F6=1396.9)	G4
4 (B2)	408 (A4b=415)	1274 (D6#=1244.5)	2211 (C7#=2217.5)	A4b
5 (A1)	463 (B4b=466.1)	985 (B5=987.7)	1365 (F6=1396.9)	B4b
6 (A2)	507 (B4=493.8)	1763 (A6=1760.0)	2451 (D7#=2489)	B4

From Table 1 the partial frequencies f_1 and f_2 were not consistent with the integer multiple of the fundamental frequency f_0. Only M1 showed f_1 (392.00 = 2×196.00) as an integer multiple of f_0 (196.00). Although the f_0 was G3 followed by f_1 as G4, the listener heard the f_2 as C4 (261.63 Hz) instead of C6♯ (1108.7 Hz). The frequency spectrum shows many overtones (harmonics/non-harmonics) in addition to C6♯ (1108.7 Hz) when the tube is tuned to C4=261.63 Hz as heard by the luthier. G3, G4, C6♯, and so forth are not the components of the C4 harmonic series. According to the FFT signal, the fundamental G3=196.00 Hz is the lowest frequency produced when the complete tube vibrates. A vibrating tube will, of course, vibrate in integer multiples of its fundamental ($f_n = n$×196.00 Hz). G4 (392.00 Hz) is a multiple of G3 (196.00 Hz) that is almost exact. A real tube never vibrates in just one mode. When struck, if the entire tube vibrates at 196.00 Hz, then the halves at 392.00 Hz, and so on. The C6♯ (1108.70=5.65×196.00 Hz) is not an integer multiple of the fundamental. All of these happen simultaneously. Although the measured dominant frequencies were centered around G3 and its partials, listeners perceived the pitch as C4. Because the measured partials do not form a harmonic series corresponding to C4, this perception cannot be explained by the classical missing fundamental phenomenon alone. Other psychoacoustic factors, such as spectral centroid, inharmonic partials, transient characteristics, resonance, or listener-dependent pitch judgment, may have influenced the perceived pitch.

Pitch interpretation is inconsistent which means that the pitch heard by listeners does not consistently match the measured frequency components or harmonic structure of the sound. Specifically:

For Tubes 2–6, the perceived note matches the fundamental frequency (f_0). For example:

Tube 2: f_0 = 396 Hz ≈ G4, perceived = G4.
Tube 3: f_0 = 391 Hz ≈ G4, perceived = G4.
Tube 4: f_0 = 408 Hz ≈ A♭4, perceived = A♭4.
Tube 5: f_0 = 463 Hz ≈ B♭4, perceived = B♭4.
Tube 6: f_0 = 507 Hz ≈ B4, perceived = B4.

In these cases, pitch interpretation was actually consistent with the fundamental frequency, even though the higher partials were inharmonic. Tube 1 is the unusual case.

f_0 = 199 Hz ≈ G3.
f_1 = 392 Hz ≈ G4 (a harmonic).
f_2 = 1080 Hz ≈ C♯6.

Yet the perceived note is C4 (261.63 Hz). Here, the listener reports a pitch (C4) that does not correspond to the measured fundamental (G3) or to a harmonic series based on G3. This is what could be described as an inconsistent pitch interpretation. The missing fundamental phenomenon occurs when the actual fundamental frequency is absent or weak, and the remaining frequencies are integer multiples of that missing fundamental, allowing the auditory system to infer it. For a perceived C4 (261.63 Hz), the spectrum should contain frequencies approximately like 523.26 Hz (2×), 784.89 Hz (3×), 1046.52 Hz (4×), 1308.15 Hz (5×), or other harmonics of 261.63 Hz. Tube 1 frequencies are approximately 199 Hz, 392 Hz, 1080 Hz. These are not harmonics of 261.63 Hz, nor are they harmonics of each other. Therefore, the data presented do not demonstrate the classical missing fundamental phenomenon.

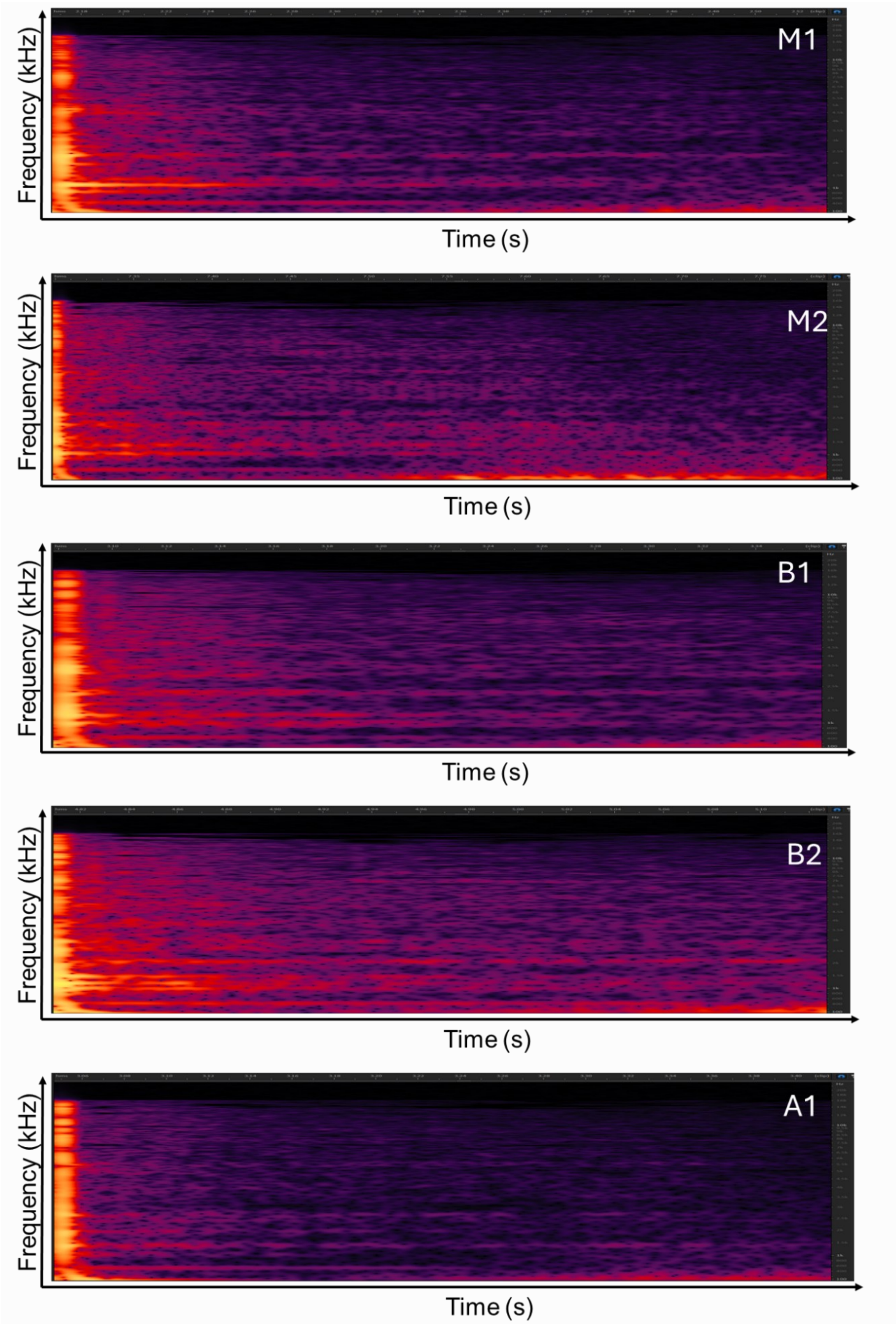
Although the measured dominant frequencies are centered around G3 and its partials, listeners perceived the pitch as C4. Because the measured partials do not form a harmonic series corresponding to C4, this perception cannot be explained by the classical missing fundamental phenomenon alone. Other psychoacoustic factors, such as spectral centroid, inharmonic partials, transient characteristics, resonance, or listener-dependent pitch judgment, may have influenced the perceived pitch. When the first harmonic of the waveform is removed, the feeling of pitch is the primary phenomena that is lacking (Howard and Angus 2017). Psychoacoustics has shown that the auditory system's natural capacity to distinguish between tones causes it to consistently assign a pitch to a complex tone if there is a sizable group of harmonics in the spectrum (Hartmann 1996). For example, a note with a pitch of 261.63 Hz will have frequency components of 523.26, 784.89, 1046.52, and 1308.15 Hz, which are integer multiples of that amount. The tone of this note is not pure. Both tube 2 and 3 showed the f_1 as B5 (987.77=2.52×392), whereas the f_0 appeared as G4 (392.00). Tube 4 showed the f_1 as D6# (1444.5=3.48×415), whereas the f_0 is A4b (415). Tube 5 showed the f_1 as B5 (987.77=2.11×466.16), whereas the f_0 is B4b (466.16). Tube 6 showed the f_1 as A6 (1760.00=3.56×493.88), whereas the f_0 is B4

(493.88). The f_0 for tube 2 to 6 are according to the note of sound perception based on the piano scale although they produce sounds with complex frequencies rather than a single distinct note.

Although the Kiruncong is commonly described as an unpitched idiophone, this classification refers to musical function rather than the absence of measurable frequencies. Each bamboo tube produces a complex spectrum containing a fundamental frequency**,** multiple partials, and one or more dominant spectral peaks. These quantities are related but not identical. Four different acoustic concepts rather than treating them as synonyms is described below:

1. The fundamental frequency (f_0) is the lowest resonance of the vibrating tube and is the physical frequency that would define the pitch of an ideal harmonic sound. In the Kiruncong, f_0 could be measured for every tube, allowing each tube to be assigned a nominal musical note for identification and comparison.
2. A partial is any resonance component of the sound spectrum. Unlike harmonic instruments, the partials of bamboo idiophones are generally inharmonic, meaning that they are not exact integer multiples of the fundamental frequency.
3. The dominant peak is the strongest component in the measured spectrum. It represents the frequency with the greatest acoustic energy but is not necessarily the fundamental frequency. In bamboo idiophones, the dominant peak may occur at a higher partial because that resonance radiates more efficiently.
4. Perceived pitch is the pitch heard by listeners. It is a psychoacoustic attribute that depends on the interaction of the spectral components and does not always coincide with either the fundamental frequency or the dominant peak. For inharmonic sounds such as the Kiruncong, the perceived pitch may be weak, ambiguous, or shifted relative to the measured fundamental.

Consequently, the musical note assigned to each Kiruncong tube should be understood as a reference note based on the measured fundamental frequency (or an agreed tuning reference) rather than evidence that the instrument behaves as a conventionally pitched melodic instrument. The designation of the Kiruncong as an unpitched instrument reflects its organological classification and performance practice, whereas assigning note names provides a practical framework for acoustic analysis and comparison among tubes. Figure 5 shows the time frequency analysis (TFA) for M1, M2, B1, B2, A1 and A2. Figure 6 shows the transcription based on the video from https://youtu.be/rPejo-ECbfU?si = uWKRTqANilgbUNma .


M1
Frequency (kHz)
Time (s)
M2
Frequency (kHz)
Time (s)
B1
Frequency (kHz)
Time (s)
B2
Frequency (kHz)
Time (s)
A1
Frequency (kHz)
Time (s)

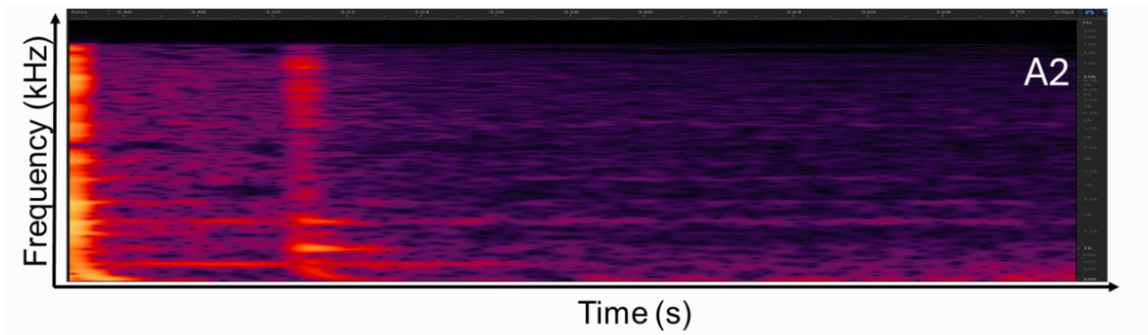


Fig. 5 The TFA for M1, M2, B1, B2, A1 and A2

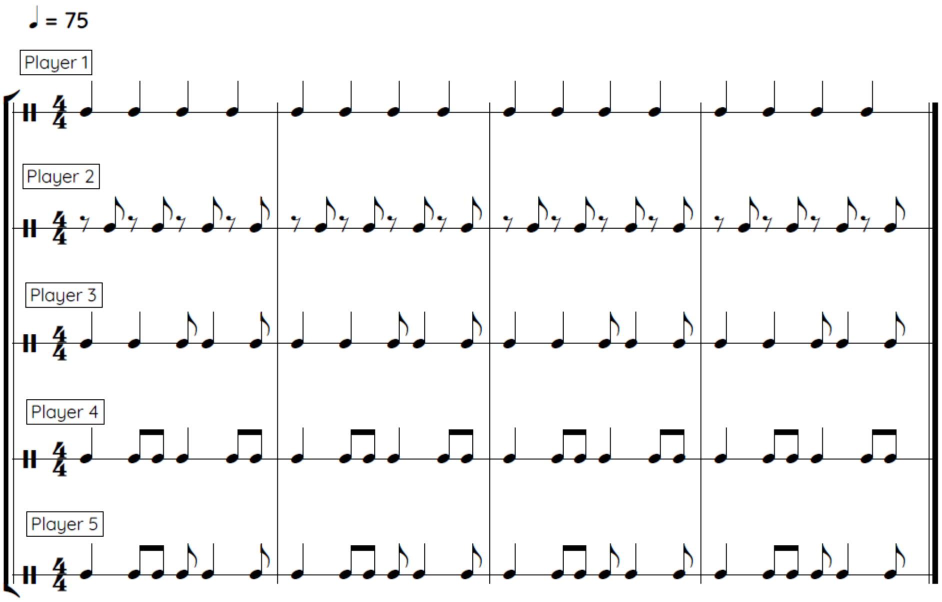


Fig. 6. The transcription base on the video from https://youtu.be/rPejo-ECbfU?si = uWKRTqANilgbUNma

In a traditional music performance, there is usually an introductory rhythmic pattern that functions as the foundation for establishing the overall tempo and stability of the ensemble. This opening section is commonly performed using a steady beat, often beginning with two minim notes or four crotchet notes to provide a clear metric structure for the other performers. In this context, percussion instruments such as drums or gongs typically initiate the basic rhythmic pattern before being answered by a second player who develops the rhythm through upbeat responses against the established steady beat. Based on the musical example in the referenced YouTube performance, one of the most distinctive aspects is the rhythmic variation produced by each bamboo tube. The third player introduces a contrasting rhythmic pattern that emphasizes the second and third beats within a 4/4 meter, while the fourth player adds quaver notes on the second beat, creating a denser and more dynamic rhythmic texture. Meanwhile, the fifth player contributes the most active rhythmic embellishments by continuously filling the upbeat spaces. This technique can be associated with the concept of interlocking, in which multiple performers contribute complementary rhythmic fragments that interweave with one another to create a complex and cohesive musical texture. According to McPhee (1966), interlocking rhythmic structures are fundamental in many Southeast Asian traditional music, particularly in creating a sense of energy, continuity, and collective ensemble interaction. Similarly, Tenzer (2000) explains that interlocking patterns generate dense rhythmic textures that can evoke heightened excitement and immersive musical experiences for both performers and listeners.

CONCLUSIONS

1. Since this study employed only one set of Kiruncong instruments, the findings are specific to that instrument set. Accordingly, caution should be exercised when extending to other Kiruncong instruments. The frequency of tubes 1, 2, 3, 4, 5, and 6 were 199, 396, 391, 408, 463, and 507 Hz, respectively with the corresponding notes G3, G4, G4, A4b, B4b, and B4.
2. This study demonstrated that the Kiruncong has distinctive acoustic characteristics arising from its bamboo construction and tuning arrangement, enabling it to function as a percussion instrument capable of producing identifiable pitches and melodic sequences rather than solely rhythmic patterns.
3. Frequency analysis revealed that each bamboo tube produces a characteristic fundamental frequency and harmonic structure, forming a tonal scale that supports melodic performance while preserving the instrument's distinctive timbre and sound color.
4. The recorded sound signals and Fast Fourier Transform (FFT) analysis quantitatively characterized the Kiruncong's spectral features, including its frequency distribution and harmonic content, providing objective evidence of the instrument's tonal and acoustic behavior.
5. The acoustic results highlight the Kiruncong's unique combination of percussive attack, sustained tonal resonance, and characteristic timbre, distinguishing it from many conventional percussion instruments and demonstrating its dual rhythmic and melodic functions.
6. The baseline acoustic dataset established in this study provides measurable frequency and spectral characteristics of the Kiruncong, enabling future comparative investigations of bamboo idiophones, tuning systems, sound production mechanisms, and indigenous musical instrument acoustics
7. The integration of traditional knowledge with modern acoustic analysis demonstrates the potential of interdisciplinary approaches in safeguarding intangible cultural heritage while enhancing its visibility within academic and cultural preservation initiatives.

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