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Frequencies Analysis on *Suling Te'dek* using Fast Fourier Transform : Ethnic Musical Analysis

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Abstract

The aim of this research was to use the Fast Fourier Transform (FFT) to analyze the frequency of notes produced by the traditional Te'dek flute of the Toraja people in South Sulawesi, Indonesia. The purpose of this research was to contribute to the preservation of the Toraja's cultural history by providing an evaluation of the Te'dek flute's tonal characteristics. The research process included recording the sound of the flute, applying the FFT to the recorded data to extract frequency values, and analyzing these values to determine the frequency of each note within an octave. What sets the Te'dek flute apart is its unique tuning process, where the maker skillfully adjusts the fingerholes' diameter using hand tools and relies on intuition to determine the sound without any external measurement. The results of the study showed that the FFT can be used to accurately determine the frequency of the Te'dek flute and that the strength of airflow in the flute's cavity plays a significant role in determining the frequency of the tone.

I. INTRODUCTION

Toraja is an ethnicity that lives in the province of South Sulawesi, Indonesia. In addition to its breathtaking terrain and vistas, the Toraja region is home to a unique musical culture [1], [2]. Traditional music is an integral part of the Torajan people's culture and is regularly used to enhance various activities, such as traditional ceremonies, rituals, and entertainment [3], [4]. The indigenous musical traditions of the Toraja people in South Sulawesi, Indonesia include a variety of traditional instruments, such as the Pa'pelle, Passuling, Pa'karombi, Pa'pompang or Pa'bas, Pa'tulali, and Pa'geso'geso [5]. However, these instruments

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have undergone a process of evolution due to a lack of interest among the younger generation in learning traditional musical instruments and their preference for modern ones. This has resulted in a situation where traditional musicians are often elderly [5]. The importance of preserving the cultural history of the Toraja people, including their musical culture, cannot be overstated [5].

One such traditional instrument is the Te'dek flute (Suling Te'dek), a wind instrument made from bamboo with a typical thickness of 1-2 mm (referred to as bulo by the Toraja people) [2], [6]. Te'dek flute professionals use their intuition and skillful finger adjustments to tune the flute, making it truly unique. Unlike modern or other traditional Indonesian flutes, each Te'dek flute is a one-of-a-kind masterpiece, reflecting the individual artistry of its maker. This exceptional craftsmanship and cultural significance set the Te'dek flute apart as a treasured symbol of the Toraja people's musical heritage. It classified as an aerophone, the Te'dek flute produces sound through the vibration of air in its cavity. It is typically played at the rambu solo' (traditional death ritual), the rambu tuka' rituals (the traditional rice harvest ceremony), and other weddings, either solo or with accompaniment. The Te'dek flute is known for its unique and challenging pentatonic tone, which varies in frequency according to the musical preferences of the Toraja region [7]. The strength of the airflow in the flute's cavity also plays a significant role in determining the frequency of the tone [8], making it difficult for inexperienced players. To date, there has been no study on the frequency of the notes produced by the Suling Te'dek. As such, it is necessary to conduct an evaluation of the tone, specifically to determine the frequency of each note within an octave. In this study, the researcher proposes using the Fast Fourier Transform (FFT) [9] to extract various signal parameters, such as frequency values, in order to analyze the tone of the Te'dek flute [10], [11].

The aim of this paper is to identify the original frequencies of each note in the Suling Te'dek, and then to compare it with the frequencies from European music. This study will provide insight into the unique tonal characteristics of the Suling Te'dek and how it compares to Western classical music. By analyzing the frequency values and other signal parameters, we aim to gain a better understanding of the Suling Te'dek and its place within the traditional music of the Toraja people. The results of this study can also provide a foundation for future research on the preservation and promotion of traditional Torajan musical culture.

II. RELATED WORKS

The following are some previous studies related to this research. The first study was a research paper entitled "Aplikasi Tuner Alat Musik Sasando Real-Time Menggunakan Teknik Fast Fourier Transform (FFT) dan Harmonic Product Spectrum (HPS)" which investigated the use of an FFT tuner to determine the frequency value of a tone. The results of this study showed that the Sasando Tuner application provided an output with a resolution of 0.5Hz, displayed the frequency spectrum, and was able to accurately provide information on the frequency of tuned strings [12].

A study titled "Identifikasi dan Aplikasi Pengenalan Spektrum Bunyi Gamelan Menggunakan Jaringan Syaraf Tiruan Pada Matlab" demonstrated that artificial neural networks can be used to identify gamelan sounds [13].

A study titled "Identifikasi Nada Antara Suling Sunda dan Suling Rekorder Dengan Menggunakan Metode Mel Frequency Cepstral Coefficients (Mfcc) Dan Dynamic Time Warping (Dtw)" evaluated the tone of the Sundanese flute and found that the system was able to identify the tones of the Sundanese flute and the recorder flute with a 70% accuracy rate [13].

III. METHODS

In this research, we used 4 phases to produce the frequency value for each *Suling Te'dek* note, shown in figure 1.

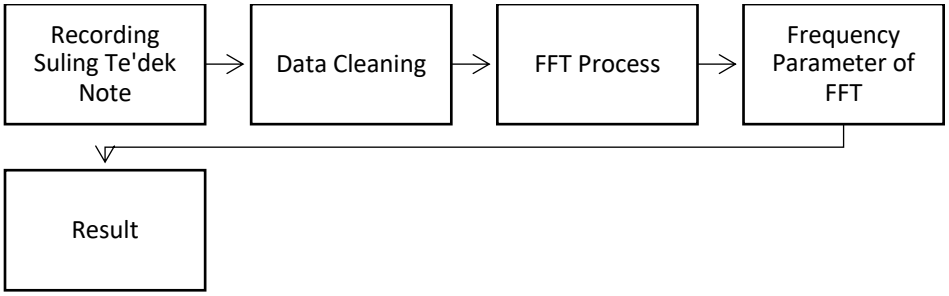

Figure 1. Research Method

In this research, we opted not to undertake any tuning alterations on the Te'dek flute, as our objective was to preserve the authenticity of its tone. The sound sample procedure involves capturing the sound of a flute. The analog signal data from the flute sound is transformed into a digital signal and recorded as a *.wav file with a predetermined sample rate at the time of sampling. The researcher has chosen to use the *.wav format because it is an uncompressed audio file, which ensures the recording's quality is not compromised. There are nine recorded notes on the Suling Te'dek, including B3, D4, D#4, E4, F#4, A5, B4, D5, and E5, with an average recording duration of 30 seconds for each note.

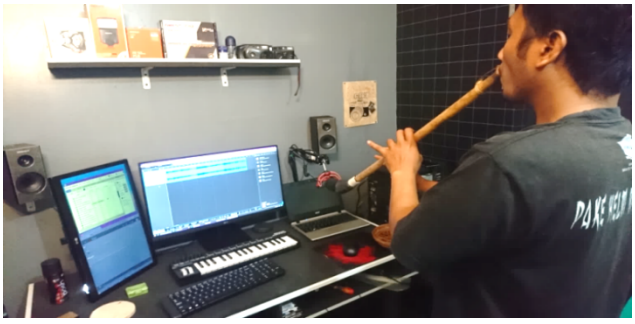

Figure 2. Flute sound recording

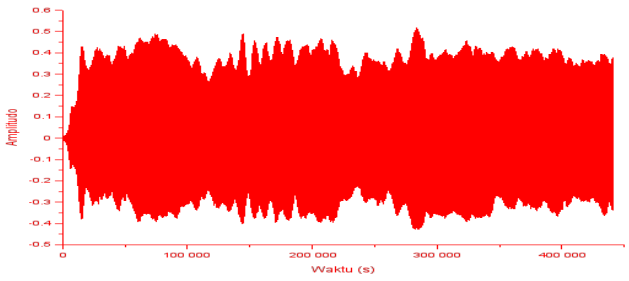

Figure 3. Flute Signal

Figure 2 shows the process of sampling flute sounds using a microphone and computer [14], [15]. The sound is then converted into a digital signal. Figure 3 shows the digital data in analog form (the sound of the flute).

The data cleaning stage removes any faulty parts of the sound signal. This is to prevent errors in frequency detection when the sound sample data is processed. In this study, only the signal duration was cut, so the sound quality was not affected. The result is a sound signal cut for ten seconds per tone. The Cubase software, a tool for editing music sounds, was used in this study..

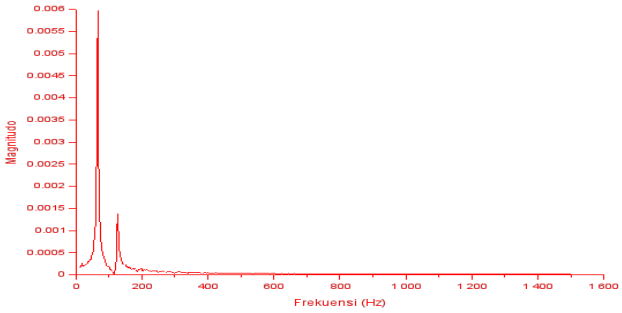

Figure 4. FFT Result

The outcome of the FFT algorithm (figure 4) is a process in which recorded tones are plotted as time domain and frequency domain signals. This process aims to determine the amplitude and frequency of the signal characteristics of the Flute Te'dek tone. Amplitude is the maximum deviation of a wave that affects the volume of a sound. The volume of a sound is proportional to the amount of energy emitted by a vibrating source. The strength and weakness of a sound are determined by the amplitude value, while frequency is the number of vibrations produced by an object per second. The techniques of Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT) can be used to transform the audio signal into frequencies (FFT) [16], [17]. DFT is a basic algorithm, but it has a longer computation time, while FFT is a more complex technique, but it has a faster computation time. FFT is used in research because it is more efficient and faster than DFT. During this phase, the researcher uses Scilab to plot the recorded notes.

IV. RESULTS AND DISCUSSIONS

The FFT analyses for each note are shown in the table below.

Tabel 1. Result of FFT in Suling Te'dek tone

No	Note	Frequency		Amplitude	
		LF	HF	LA	HA
1	B3	66,5	125,5	-0,25	0,5
2	D4	77,5	153	-0,1	0,2
3	D#4	82,5	163,5	-0,15	0,2
4	E4	85,5	168,8	-0,05	0,14
5	F#4	96,1	190,5	-0,06	0,08
6	A4	115	225	-0,07	0,17

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7	B4	125,7	247	-0,15	0,4
8	D5	152,5	300,5	-0,2	0,27
9	E5	171,5	341	-0,14	0,23

Based on the data in table 1, the Suling Te'dek has two generated frequencies in one blow, as indicated by the "LF" and "HF" columns, which stand for "low frequency" and "high frequency", respectively. The frequency values in these columns are generally different, with the low frequency being lower than the high frequency.

In addition to the two-frequency characteristic of Suling Te'dek, it's also possible to draw some other observations and conclusions from the table, such as:

- The amplitude of the notes varies, with some notes having a higher amplitude than others. For example, note 1 (B3) has a higher amplitude (0.5) than note 3 (D#4) (-0.15)
- The range of the frequency for all notes lie between 66.5-171.5 with a difference of 105 Hz.
- Notes E4 and D#4 have quite close frequencies and amplitudes .
- The table indicates that the range of the amplitude values is quite wide: from -0.25 to 0.5, It means that the amplitudes of the notes have a high variation from the lowest to the highest note.

It is feasible to conduct a comparison between the tonal characteristics of the Suling Te'dek and those of European standard music, however, it is important to consider that traditional Torajan music and Western classical music possess distinct musical scales, tunings, and cultural contexts. The Suling Te'dek has 9 distinct notes in its scale, such as B3, D4, D#4, E4, F#4, A4, B4, D5, E5.

The Suling Te'dek is classified as a nonatonic instrument, as it has a nine-note scale. This differs from Western classical music which commonly utilizes a 12-note equal temperament scale. Additionally, the intervals between the notes in the Suling Te'dek's scale may be different from the fixed intervals found in a Western standard scale (Modern Flute). This discrepancy can result in the Suling Te'dek producing a unique and distinct sound when compared to Western classical music.

Furthermore, the frequency values within the Suling Te'dek's scale may not align with the standard tuning of A4=440Hz utilized in Western classical music. Western classical music possess a fixed tuning system, while traditional Torajan music allows for more flexibility in tuning, as musicians can adjust the instrument to suit the environment or personal preferences.

Tabel 2. Frequency Comparison of Suling Te'dek and Western/European Standard Music.

Key/Tone	**Suling Te'dek**		**Western/European Standard**
	LF	**HF**	
B3	66,5	125,5	246.94
D4	77,5	153	293.66
D#4	82,5	163,5	311.13
E4	85,5	168,8	329.63
F#4	96,1	190,5	369.99
A4	115	225	440.00
B4	125,7	247	493.88
D5	152,5	300,5	587.33
E5	171,5	341	659.26

The table 2 compares the frequency of each note of the Suling Te'dek, a traditional Indonesian instrument, with the frequency of Western standard music. Using FFT (Fast Fourier Transform) analysis, we found that the Suling Te'dek has lower frequency compared to Western standard music, which makes it sound unique. However, there are variations in the frequency values of each note between the Suling Te'dek and Western standard music.

In addition, we can see that the Suling Te'dek is traditionally used in specific cultural contexts, such as traditional ceremonies and rituals, and holds deep symbolic significance within Torajan culture. This is different from Western music which is widely used in many settings.

From the data provided, it can also be observed that the range of frequencies of the Suling Te'dek is different than the Western standard, which further emphasizes the uniqueness of Suling Te'dek and its distinctive characteristics in comparison to Western standard music.

It is worth noting that the precision of the measurement and the cultural context in which the Suling Te'dek is used may affect the results, so more research is needed to fully understand the characteristics of the Suling Te'dek's sound and how it compares to Western standard music.

V. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the present study aimed to conduct a frequency analysis of the traditional Indonesian instrument, Suling Te'dek, using the Fast Fourier Transform (FFT) algorithm and compare its frequency values to those of Western standard music. The results show that the Suling Te'dek has lower frequency values compared to Western standard music, which demonstrates that the Suling Te'dek has a distinct and unique sound when compared to Western music.

It was found that the physical dimensions of a flute may have a significant effect on its acoustical properties, however, this was not studied in this present research. Additionally, factors such as the wind pressure applied, the setting of the sinto, and the distance between the pitch holes may also have an impact on the tone of the flute. It is important to consider these factors in future studies when designing or playing a flute in order to attain a desired tone.

Furthermore, the cultural context of the Suling Te'dek is an important consideration, as it is typically employed in specific cultural contexts such as traditional ceremonies and rituals and holds deep symbolic significance within Torajan culture.

Based on the findings of this study, it is recommended that further research be conducted to fully understand the intricate relationship between the acoustical properties of the Suling Te'dek and its physical dimensions. Additionally, it is important to consider the cultural and symbolic context of the Suling Te'dek when studying it, and to continue to preserve and promote traditional Torajan musical culture.

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