Saron Demung Instruments Timbre Spectrum Comparison Study on The Gamelans *Sekati* from *Karaton Ngayogyakarta*

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Abstract. **The aim of this research is to compare the timbre spectrums of *Saron Demung* Instruments of gamelans *Nagawilaga* and *Gunturmadu* of *Karaton Ngayogyakarta*. These gamelan, as a set of traditional Javanese ensemble, are a *pelog* scale, seven scale in one octave.**

Sound of *Saron Demung* Instruments are recorded by sound software. This software can display waveform in time domain and spectrum in frequency domain. The fundamental frequency is shown directly by software. Other peak frequencies can be traced by shifting the cursor on top of it. The accuracy of frequency that can be produced is 1 Hz

Fundamentals frequencies of *Saron Demung* of gamelan *Nagawilaga* are higher than of *Gunturmadu*. The location of the harmonic frequencies are not always consecutive, but sometimes punctuated by another frequency. The number of harmonics or timbre of each instruments of *Nagawilaga* are different rather than of *Gunturmadu*..

Keywords: *Gamelan, Saron Demung, Nagawilaga, Gunturmadu*

1. INTRODUCTION

Gamelan is a term for various types of orchestra played in Indonesia. It is the main element of the Indonesian traditional music. Each gamelan is slightly different from the other; however, they all have the same organization, which based on different instrumental groups with specific orchestral functions. The instruments in a gamelan are composed of sets of tuned bronze gongs, gong-chimes, metallophones, drums, one or more flute, bowed and plucked string instruments, and sometimes singers. In some village gamelan, bronze is sometimes replaced by iron, wood, or bamboo. The most popular gamelan can be found in Java, and Bali.

The gamelan plays many roles in traditional Javanese society: from religion and ceremony to education and entertainment. In recent years, recordings of gamelan music have become available in the West [1, 2, 4, 13]. The gamelan ensemble can be characterized as music based on communal expression. The melody of a single instrument cannot be conceived as separable from the whole sound of the ensemble. Most gamelan instruments are tuned to definite pitches corresponding to two kinds of tuning system (*laras*): five-tone *slendro* and seven-tone *pelog*.

Saron is a generic term for a keyed instrument with six or seven keys that covers one octave of either the *slendro* or *pelog* tuning system. The saron family of instruments are *saron demung*, *saron ricik*, and *saron panerus*. They are metallophones with six or seven bronze keys placed on a wooden frame which serves as a resonator. The r*icik*, which has thick keys provides the medium octave of the saron group. The *saron demung*, which has thick keys (narrower than the *ricik*'s keys) provides the high octave of the saron group. The *saron panerus* or peking, which has thick keys narrower than the *saron demung*, provides the highest octave of the

saron group. It provides the core melody (*balungan*) in the gamelan orchestra.

Among the sarons, Saron Demung has the largest metal bars and produces the lowest sound. It's pitches are one octave lower than the Saron Ricik. Like those of Saron Ricik and Saron Panerus in Saron Demung, the higher the pitch the smaller the bar. The measurements of the bars are approximately 35.5cm. long and 9 cm wide.

All metal bars are placed on a wooden case which acted as a resonator. At each end of the metal bar, a hole is drilled so that a pin can insert through the hole into the wooden case. Between the metal bars and the wooden case, there are small squares of plaited rattan. There is a hole in each plaited rattan so that the pins, which pass through the metal bars, can pass through these plaited rattans too. The metal bars rest on these plaited rattan. The purpose of these plaited rattan is to lift the metal bars above from the wooden case to avoid damping sound. All bars are secured loosely onto the wooden case in this method.

The *sarons* are struck with a mallet (*tabuh*). Typically the ***striking*** mallet is angled to the right to produce a fuller sound. On repeated notes, the note is usually dampened half a beat before it is struck again [6]. According to orchestral function Saron group as Nuclear Theme.

Sekaten is a week-long religious Islamic festivity falling in the month of *Mulud* of the Javanese calendar (the Javanese year is eleven days shorter than the Western one). Ceremonies in Surakarta, Yogyakarta, and Cirebon (on the north coast) celebrate the birth and death of the Prophet Mohammed. And in Central Java the gamelan takes a very special sound – the powerful and mystical sound of the four *gamelan sekati* – *Nagawilaga* and *Gunturmadu*- two each in the courts of Surakarta and Yogyakarta [10, 12, 13, 14].

Javanese sources attribute the origin of *Gamelan Sekaten* to the nine holy men (*Wali Sanga*), advisors to the first Sultan of Demak, the 16th century Islamic kingdom. However Kunst [the renowned Dutch ethnomusicologist] suggests that the *sekaten* ensemble had already existed for Hindu ceremonial music before the arrival of Islam in Java [2].

The size of the instruments is about three times bigger than that of the regular gamelan. Mallets and hammers are consequently big and heavy, including buffalo horns weighted on the striking head with lead. The tuning of the *sekaten* ensemble is the seven-tone *pelog,*

The study of the Javanese gamelan has been conducted by experts from both Western and culture of the East. Scientific investigation with measurement of Javanese gamelan tones have been pioneered by a British physiologist AJ Ellis in 1884 on the hose and the voice on the barrel *pelog*. Followed in 1933 by renowned Dutch musicologist Jaap Kunst [3] who has conducted investigations on the gamelan tone system intensively by measuring the frequency of vibration instrumentnya. The main tool used at the time was the thoroughness monochord rely on the ability of hearing (ears) a person. Then in 1969, Wasisto Surjodiningrat et al. also investigate the frequency of vibration-instrument instrument gamelan on various devices gamelan's best and representative of Kraton (Sultanate, Pakualaman, Kasunanan, and Mangkunegaran), government agencies (RRI), and individuals. The instrument used more modern than the previous, Cathode Ray Oscilicop [3].

The investigation of the gamelan whether committed by Jaap Kunst and S. Wasisto et al. limited to measuring the fundamental frequencies, ie frequencies that have the highest amplitude, but can not display color frequencies that make up the accompanying sound is often called the timbre in the study of music theory. Timbre is a trait of the human voice or instrument because of different intensity and number of harmonics and sub harmonics (overtones) that can distinguish one instrument with another instrument. Timbre analysis utilizing Fourier transformation, a transformation that changes the waveform in time domain to the form of spectrum is in frequency domain. Fourier spectra do an excellent job of identifying the frequency content of individual notes, it is as easy here to assign fundamentals and overtones.

This article examines the color of sound of each instrument for *Saron Demung* on gamelan *Nagawilaga* and *Gunturmadu*. The results can be used as prior study in order to make standardization on gamelan tone.

2. RESEARCH METHODS

Data is collected in the Sultanate Palace *Ngayogyakarta*, Indonesia. The musician blends is a palace courtiers who was assigned as the gamelan. The appointment was recommended by *Panghageng* hammers *Kawedanan Hageng Kridhamardawa ie Kraton Ngayogyakarta GBPH Yudhaningrat.*
Microphones to capture sound placed near each instrument. These microphones are connected to a portable computer that already contains a sound processing software. The resulting sound is recorded and stored. Preliminary analysis carried out after each recording to determine the consistency of the resulting spectrum. Further analysis conducted in the laboratory.

Audio processing software displays the waveform of the signal intensity in graphical form as a function of time. To obtain a frequency spectrum of intensity as a function performed by turning on the spectrum analyzer menus. This menu works based on fast Fourier transform (Fast Fourier Transform, FFT). The frequency range displayed on the audio, which is 20 -20

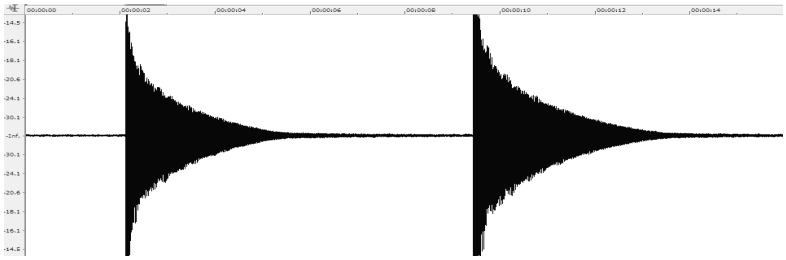
000 Hz. By turning on the statistics menu, can be displayed directly from the fundamental frequency of the signal being analyzed. The next peak frequencies can be determined by shifting the cursor on top of it. The accuracy that can be generated frequency is 1 Hz.

3. RESULTS AND DISCUSSION

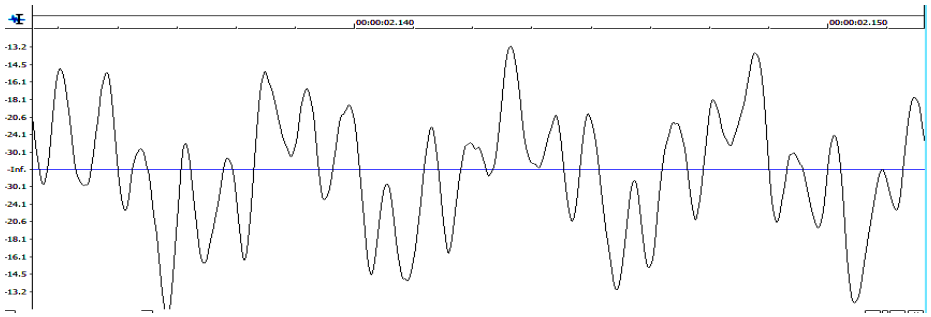
Fig. 1. display waveforms for Saron Demung Gamelan *Nagawilaga*. **Fig. 2** shows color spectrum of sound for gamelan Saron Demung *Gunturmadu*. Initial spectrum of *Nagawilaga* (Figure 1. (a)) showed a sharper decrease in intensity compared with those obtained from Saron *Gunturmadu* (Figure 2 (b)), which displays a more gentle change in intensity. If both spectra are magnified by considering the shorter will be seen the spectrum shown in Figure 1 (b) for a *Saron Demung* instrument *Nagawilaga* and Figure 2 (b) for instrument a gamelan *Saron Demung Gunturmadu*. Spectrum owned instrument number 1 of gamelan Saron second Ricik have similarities, although the *Nagawilaga* starting with the top of the hill with three peaks followed by following the hill reduced. In *Gunturmadu*, the spectrum begins with two peaks hilly and steep one in turn.

Spectrum is shown in Figure 1 (c) and 2 (c) is the result of Fourier transformation, which converts a function of time into a function of frequency.

The frequency with highest intensity in each spectrum is the fundamental frequency. Fundamental frequency for a *Saron Demung* instrument *Nagawilaga* at 213 Hz. This frequency is followed by peaks located at, 329, 390, 427, 570, 605, 641, 819, 999, 1033, 1073, 1165, 1180, 1211, 1394, and 1428 Hz. Fundamental frequency for *Saron Demung* gamelan *Gunturmadu* at 198 Hz, followed by, 336, 391, 536, 831, 1018, 1215, and 1463 Hz.



(a)



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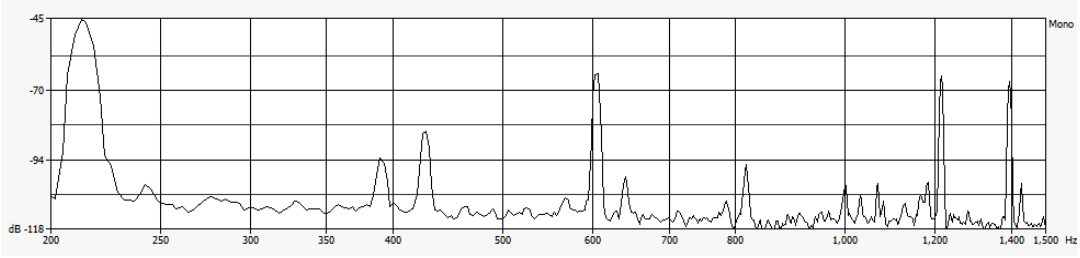
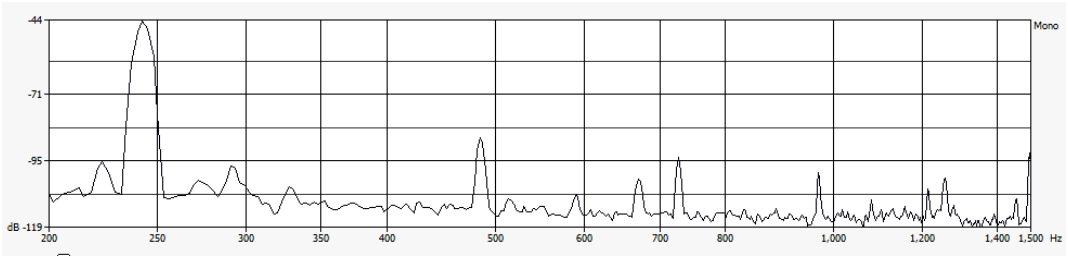
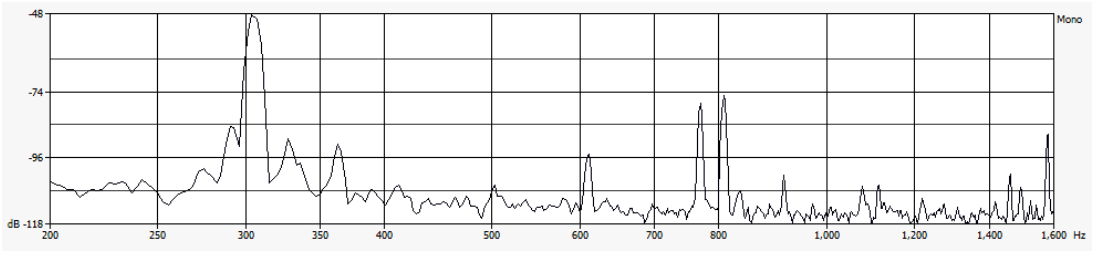


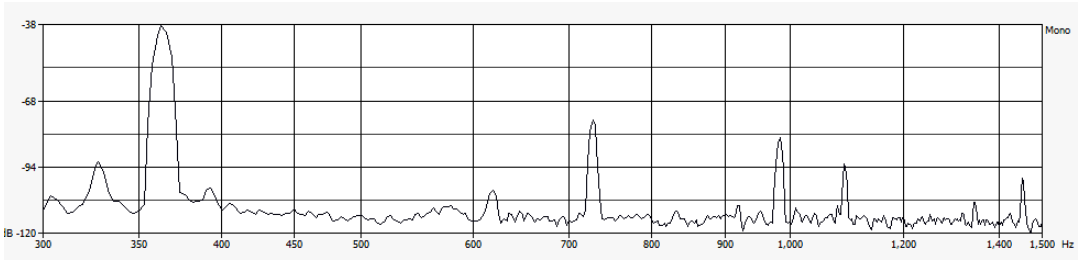
(c1)



(c3)

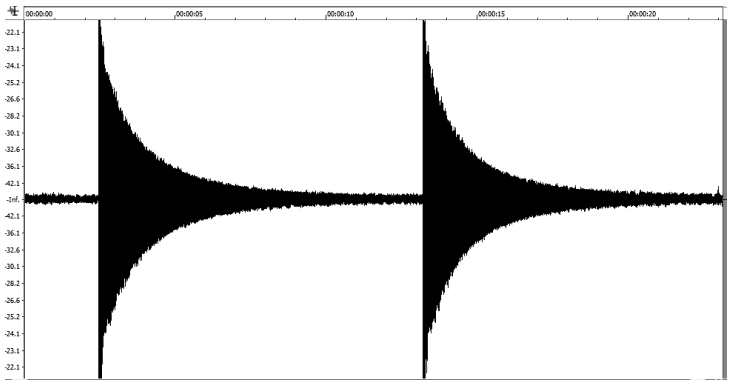


(c5)

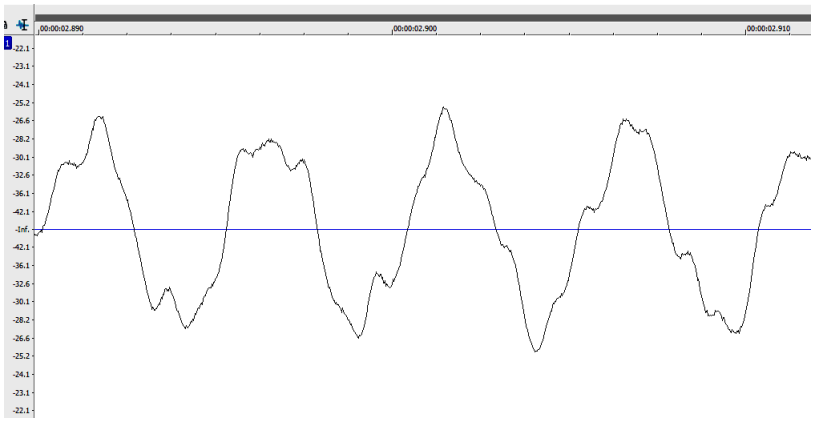


(c7)

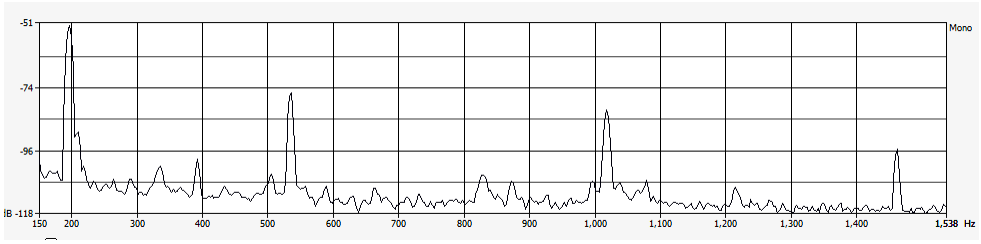
Fig. 1. Instrument #1 *Saron Demung* gamelan *Nagawilaga*; (a) waveform as a function of time obtained, (b) magnification of (a), and (c) as a function of the frequency spectrum (Fourier transform of the spectrum (a)). c1, c3, c5, c7 for instruments #1, #3, #5, and #7 respectivly.



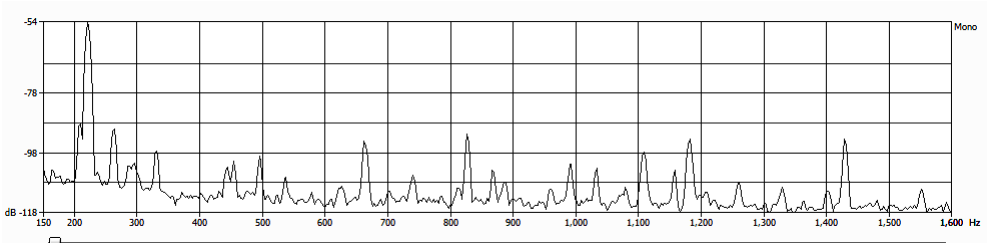
(a)


00:00:02.890
00:00:02.900
00:00:02.910

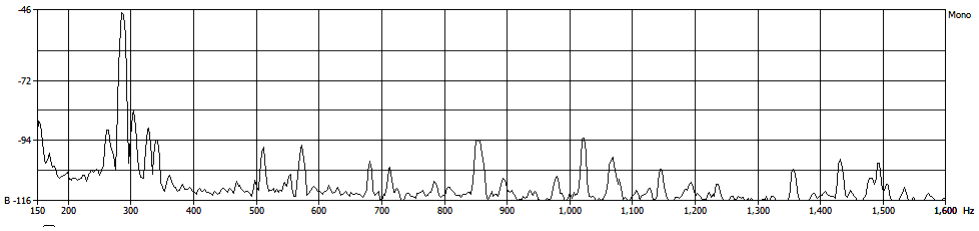
(b)


Mono
-51
-74
-96
dB -118
150 200 300 400 500 600 700 800 900 1,000 1,100 1,200 1,300 1,400 1,538 Hz

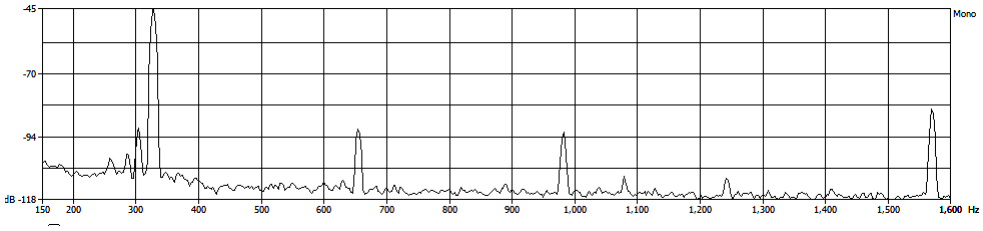
(c1)


Mono
-54
-78
-98
dB -118
150 200 300 400 500 600 700 800 900 1,000 1,100 1,200 1,300 1,400 1,500 1,600 Hz

(c3)


Mono
-46
-72
-94
B -116
150 200 300 400 500 600 700 800 900 1,000 1,100 1,200 1,300 1,400 1,500 1,600 Hz

(c5)



(c7)

Fig. 2. Instrument #1 *Saron Demung* gamelan *Gunturmadu* (a) waveform as a function of time obtained instrument 1, (b) magnification of (a), and (c) as a function of the frequency spectrum (Fourier transform of the spectrum (a)). c1, c3, c5, c7 for instruments #1, #3, #5, and #7 respectivly.

Table 1 presents the fundamental frequency for each instrument *Saron Demung* for both gamelans. Nominal fundamental frequency of the two are not exactly the same, but with the difference between 30 and 60 Hz for each instrument. We compare the results measured by Wasisto [3] using CRO. The methods can only shows the fundamental frequency and filtered higher frequencies. The result shows the similarities each instruments, with slightly different both for *Nagawilaga* and *Gunturmadu*. The slightly different may be assume due to the characteristic change of instruments caused by different time of measure (more than 40 years).

In general, the fundamental frequency of the Gamelan *Nagawilaga* higher than *Gunturmadu*. This is indicated by Fig. 3. The trend increase in the gamelan are also almost similar. It is interested to normalized these fundamental frequencies to instruments # 1 fundamental frequency as shown in Fig. 4. Both line are coincide. The results indicate that without regard the different fundamental frequencies, their tendencies are equal. This result can be used as reference to standardize the tone of gamelan as western music.

The timbre or sound color of each instruments can be obtained by measured the frequency of each peak of their spectrum. Every frequency on every instrument normalized with reference to the fundamental frequency on the instrument.

The results of the normalizations outlined in Table 2. Figures in bold is the number (and almost, in a reading error) round, which means that at these frequencies is the harmonics frequency.

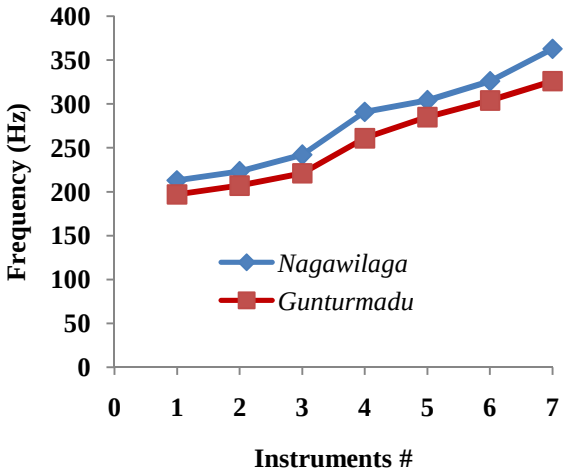


Fig. 3. Graph comparison of the fundamental frequency of gamelan *Saron Demung Nagawilaga* and *Gunturmadu*.

Table 1.
Fundamental frequency (in hertz) for each *Saron Demung* instruments of gamelans *Nagawilaga* and *Gunturmadu*. Comparison the results of this study and of Wasisto [3].

Instruments number	This study			Wasisto [3]		
	Nagawilaga	*Gunturmadu*	differencies	*Nagawilaga*	*Gunturmadu*	differencies
#1	213	197	16	214	198	16
#2	223	207	16	224	207	17
#3	242	221	21	248	220	28
#4	291	261	30	293	267	26
#5	304	285	19	308	288	20
#6	326	304	22	331	304	27
#7	363	326	37	368	328	40

The location of the harmonic frequencies are not always consecutive, but sometimes punctuated by another frequency. This situation is different from the assumption has been that states that the percussion instruments there is no harmonic function. This situation is true when comparing it with the fundamental frequency between instruments, the normalization is done from a higher to instrument #1 The number of harmonics of both gamelan for each instruments are different except for instruments # 7. The number peaks those indicate their characteristic timbre different for each instruments.

The first instrument of *Nagawilaga* has five harmonics frequencies but there is no fourth harmonics. The condition is different of *Gunturmadu* with two harmonics only. These conditions also occurred for other instruments. The timbre differences of instruments may be due to the difference both in material and manufacture

This result challenge to compare with more other gamelan in order make standardization due to their different timbre, although the tendencies of fundamental frequencies are similar.

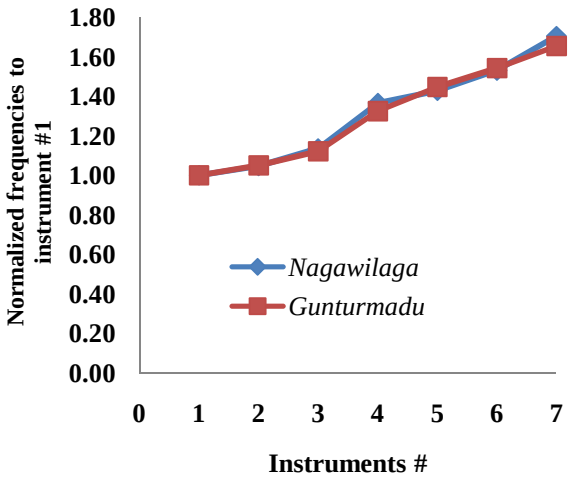


Fig. 4. Comparison of normalized frequencies to the fundamental frequency of instruments # 1 *Saron Demung* gamelan *Nagawilaga* and *Gunturmadu*

Table 2. The timbre of each instrument of *Saron Demung* on gamelan *Nagawilaga* and. *Gunturmadu*. Frequency peaks are normalized to the fundamental frequency of each instruments.

Peak order	*Nagawilaga*							*Gunturmadu*						
	#1	#2	#3	#4	#5	#6	#7	#1	#2	#3	#4	#5	#6	#7
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.54	1.09	1.21	1.05	1.08	1.11	1.71	1.71	**2.01**	1.19	1.10	1.06	1.08	**2.00**
3	1.83	1.77	**2.01**	1.18	1.19	1.56	**2.01**	**1.98**	2.43	1.33	1.16	1.15	1.12	**3.01**
4	**2.00**	**2.00**	2.45	1.76	**2.01**	1.66	2.71	2.72	2.61	1.49	**2.01**	1.20	1.67	3.32
5	2.68	2.64	2.78	1.87	2.53	**2.01**	**3.01**	4.22	2.85	**2.01**	2.66	1.79	1.82	3.81
6	2.84	2.76	**3.01**	1.91	2.66	2.56	3.71	5.17	**3.03**	2.06	2.81	**2.01**	**1.99**	4.82
7	**3.01**	**3.00**	**4.01**	**2.02**	**3.02**	2.67		6.17	3.48	2.25	**3.02**	2.39	2.24	
8	3.85	3.07	**5.02**	2.36	3.55	**3.02**		7.43	4.12	2.43	3.82	2.50	2.38	
9	4.69	3.83	5.20	2.88	3.67	3.67			4.25	2.84	**4.02**	**2.99**	2.72	
10	4.85	**4.01**	5.21	2.93	4.81	**4.03**			4.34	**3.00**	4.82	3.59	2.80	
11	**5.04**	4.61	6.19	3.53	4.91	4.76			**5.00**	3.34	**5.02**	3.75	**2.99**	
12	5.47	4.76		3.88	5.20				5.24	3.74	5.81	**4.02**	3.36	
13	5.54	**5.00**		**4.02**					5.45	3.93		4.76	4.91	
14	5.69	5.23		4.25					6.25	**4.00**		**5.02**		
15	6.54	5.44		4.98					7.10	4.22				
16	6.70	5.55								4.67				
17		**6.01**								**5.02**				
18		6.47								5.24				
19										5.34				
20										5.70				
21										**6.02**				
Number harmonics	5	6	5	4	3	4	3	2	5	**6**	5	5	3	3

4. CONCLUSION

Fundamentals frequencies of *Saron Demung* of gamelan *Nagawilaga* are higher than of *Gunturmadu*. The location of the harmonic frequencies are not always consecutive, but sometimes punctuated by another frequency. The number of harmonics of each instruments of *Nagawilaga* are different rather than of *Gunturmadu* those equal. It is important to compare with more other gamelan in order make standardization due to their different timbre, although the tendencies of fundamental frequencies are similar.

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