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EFFECT OF HUMIDITY ON THE MEMBRANE VIBRATION OF MUSICAL INSTRUMENT KOMPANG

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ABSTRACT

This paper presents the effect of humidity on the goat skin membrane of traditional musical instrument kompang. Three kompang samples with similar size of 25 cm diameter were exposed to three different relative humidity (RH) conditions (50% RH, 70% RH and 90% RH) under the Climate Chamber. The tension and the vibration frequency were measured every 8 hours in anechoic enclosure. It is found that after 48 hours of humidity exposure, the tension of the membrane reduced by 6.2% for 50% RH, 13.1% for 70% RH and 21.5% for 90% RH. The frequency of the sound produced by the membrane also lowered by 4.6% for 50% RH, 18.7% for 70% RH and 26.4% for 90% RH. The goatskin membrane is sensitive to the humidity so that the sound changes to lower frequency as the humidity increases. The lowering frequency is due to the tension lost of the goatskin membrane.

Key words: Humidity, Goatskin membrane, Musical instrument, Kompang.

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1. INTRODUCTION

Traditional musical instruments are one of a kind and unique which can represent a cultural value of specific continent [1]. Some studies for the others traditional musical instruments have been done before, for example, *tampani* [2], *wadaiko* [3], *angklung* [4], *kantele* [5], additionally gong and *gymbals* [6]. Those musical instruments have been explored in different viewpoints by researchers, as some determined the scientific models to represent the vibration attributes. Research regarding kettledrums has been reported by Rhaouti [7]. For snare drums are found in Rossing [8] and Avanzini [9]. There is also a research about sound reproduction of traditional instruments such as generation of new *kompang* sound by utilizing electronic musical instrument [10].

In this study, musical instrument *kompang* with goatskin membrane was investigated to see the change in tension and sound frequency represented by its membrane vibration frequency under different relative humidity.

The *kompang* defined in this research is the traditional percussion instrument found in Johor, Malaysia. This instrument contains two main parts: membrane and rigid shell made of wood to hold the membrane (See Figure 1). The membrane of the *kompang* is tightly attached to the frame of the shell. Since the shell is manually fabricated, the shape is not completely round. There is a slightly inconsistent round shape of the goat skin membrane to the end of shell [1]. There are many type of *kompang* according the size. It varies but the diameter of the membrane around 22 cm to 35 cm. The height variation of the shell in the range 4 cm to 6 cm [1]. Larger types of *kompang* is normally called *tom-toms* [11].

Hitting on percussion musical instrument *kompang* membrane displaces the membrane. The displacement can be various modes attributed to the characteristics of membrane [12]. The musical instruments are generally classified by the type whether string, drum or woodwind, with respect of its physical structures. Every musical instrument has unique sound attributed to type of the instrument and becomes the trademark [13]. Some researchers even disassemble the segment of the musical instrument to collect more data about that musical instrument styles and trademark, for better musical instrument information and data for documentation [14].

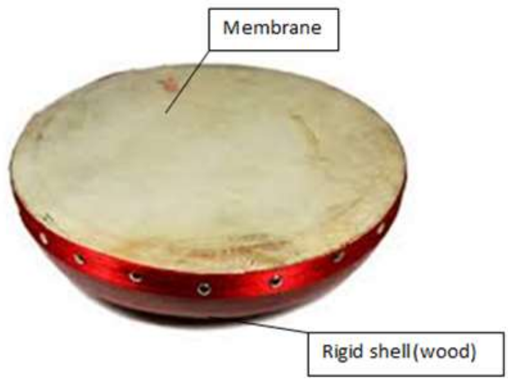

Figure 1 Traditional Kompang found in Johor Malaysia

By looking at the parts, the physical structure of the traditional musical instrument *kompang* is almost similar to the snare drum [6] and the timpani drum [15], having rigid shell and round membrane. The sound produced however is different with unique characteristic depending the material and the size of the shell and the membrane.

The musical instrument characteristic is important, as it is a profound representative the cultural values in some region as stated by Karjalainen [5] who studied traditional musical instrument *Kantele* from Finland.

There are some investigations have been conducted to see the effect of the materials to the sound produced by traditional instruments [16-18]

This research presents the investigation of humidity to sound produced by the membrane of *kompang* under various humidity conditions.

2. EXPERIMENTAL METHOD

There are two types of experiments involved in this study. Exposing *kompang* samples to the different relative humidity (50% RH, 70% RH, 90% RH), and measuring the membrane tension and frequencies every 8 hours until 48 hours in total.

The humidity was controlled inside Memmert Climate Chamber HPP 750 as shown in Figure 2. This was to ensure each kompang was exposed to different humidity for a specific period of time to see the effect of humidity on the tension and frequencies of kompang.

This study was conducted on three samples of kompang with same size of 25 cm diameter. The experiment was monitored in 48 hours. Every 8 hours the tension and the frequency are tested and recorded.

Figure 2 Three samples was exposed to humidity in Memmert Climate Chamber HPP 750.

Figure 3 Tension measurement using Tama Tension Watch.

Figure 4 Experimental setup to measure the frequency of membrane using Polytec PDV-100.

2.1. Tension Measurement

The Tension of membrane was measured by using Tama Tension watch at the center of the membrane as shown in Figure 3. The recorded results are tabulated to see the tension trends in different humidity environment.

2.2. Vibration Frequency Measurement

The sound of *kompang* is represented by the vibration of the membrane. The sound is produced dominantly by the bending mode of the membrane, the maximum displacement is at the center [18].

Measuring the frequency was conducted in an anechoic enclosure. The vibration frequency acquired by non-contact vibration measurement Laser Doppler Vibrometer (LDV) - Polytec PDV-100 as shown in Figure 4.

The experimental procedures are the following:

- Setting up the apparatus as shown in Figure 4.
- Boot up the computer and PDV-100.
- Open up the laser cover and modify the laser for focusing.
- Calibrate the PDV-100 by utilizing Kistler Portable Shaker Accelerometer Calibrator Type 8921.
- With the assistance of Vernier Height Gauge, lift the mallet up to 25 cm and release to hit the center point of circular membrane and record the frequencies of the membrane.
- Determine the frequencies of the membrane from the generated graph in the frequency domain.
- Repeat the step 5 to step 7 for the other sample.
- Shut down the PDV-100 and analyze the collected frequency results.

3. RESULTS AND DISCUSSION

Table 1 shows the tension reading taken using Tama Tension Watch for all three kompang that have been used in this study.

Table 1 Membrane tension records

	Membrane Tension (N)		
Time (hours)	**50% RH**	**70% RH**	**90% RH**
8	80	82	79
16	79	81	75
24	78	79	72
32	77	76	68
40	76	74	65
48	75	73	62

The trend of the membrane tensions are shown in Figure 5. It is observed that the tension of all three *kompang* experienced different humidity show decreasing tension at a different rate. It clearly shows that the higher the relative humidity environment of *kompang* exposure, the higher the decrease of tension. Abdullah [1] predicted that the sound of *kompang* can be influenced by the surrounding moisture and humidity. The current results support the previous prediction that the tension of membrane is changed under different humidity.

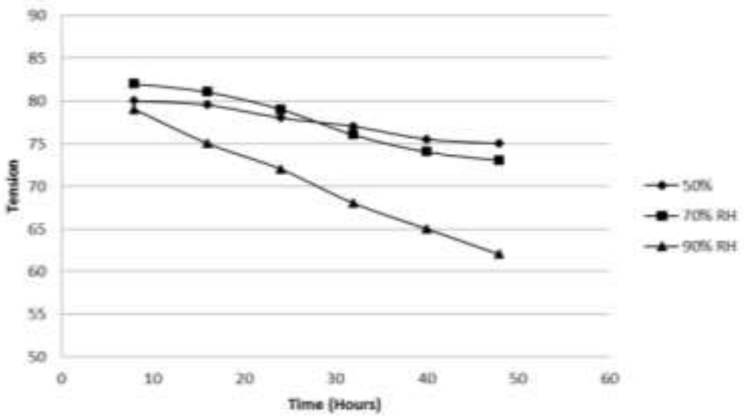

Figure 5 The decrease in tension for all three kompang during experiment.

Figure 6 shows the reduction percentage of tension for three samples after 48 hours of humidity exposure. From the graph, the reduction of the membrane tension expose to 50% RH is 6.2%, for 70% RH is 13.1% and for 90% RH is 21.5% reduction of tension from the initial tension value. The graph indicates that the tension reduction is directly proportional to the relative humidity exposure.

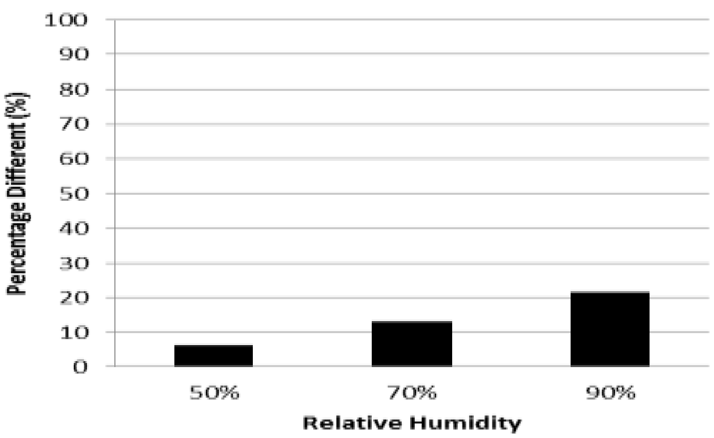

Figure 6 Percentage of tension different after 48 hours of humidity exposure.

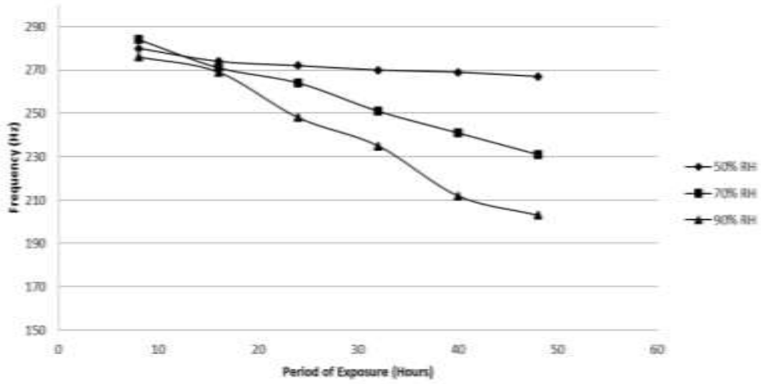

Figure 7 Frequency reduction of the membrane after 48 hours of exposure

Table 2 Kompang frequency results

	Membrane Frequency (Hz)		
Time (hours)	**50% RH**	**70% RH**	**90% RH**
8	280	284	276
16	274	271	269
24	272	266	248
32	270	251	235
40	269	241	212
48	267	231	203

Table 2 shows the frequency reading taken using Polytec PDV-100. The graph representation of the frequency taken from Polytec PDV-100 is shown in Figure 7. It is observed that the membranes experience decreasing frequency with different rates. The result show that the membrane produce lower frequency when it is exposed under higher humidity environment. This fact compliment the prediction from Fletcher [11] that the frequency of percussion instrument can be affected by the surrounding moisture and humidity.

Figure 8 shows percentage of reduction of frequency for all three *kompang* after 48 hours of humidity exposure. From the graph, the reduction of frequency for *kompang* expose to 50% RH is 4.6%, for 70% RH is 18.7% and for 90% RH is 26.4% reduction of frequency from the initial frequency values.

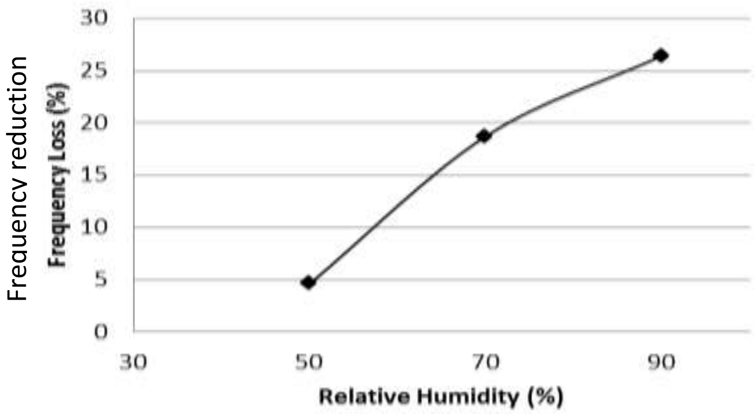

Figure 8 Frequency reduction on kompang after 48 hours of exposure to different humidity.

The trend of the graph in Figure 9 shows that the frequency reduction increases as the relative humidity exposure getting higher.

4. CONCLUSIONS

Carefully designed methodology in this study has led to a firm conclusion that the musical instrument *kompang* can be significantly affected by humidity.

The results reveal that due to the decrease tension on higher humidity, the sound produced by the membrane also decreases as indicated by vibration frequency of the membrane.

The sound produced by the membrane when the humidity level 90% can be decreased up to 26.4%. When the humidity maintained in 2 days (48 hours), the sound produced can even further drop from 276 Hz to 203 Hz. The humidity is found to be very sensitive to the goatskin membrane.

In the future, it is recommended to find the replacement for goat skin membrane on *kompang* to withstand in humid environment. It is therefore maintaining the sound quality in any condition and standard frequency can be set in *kompang* to enable paying with other modern musical instruments.

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REFERENCES

[1] Abdullah, M.H. Kompang: an organological and ethnomusicological study of a Malay frame drum, (2005). PhD Thesis, Newcastle University.

[2] Bertsch, M. Vibration patterns and sound analysis of the Viennese Timpani, Proceedings ISMA, (2001).

[3] Ono, T., Takahashi, I., Takasu, Y., Miura Y., Watanabe U. Acoustic characteristics of Wadaiko (traditional Japanese drum) with wood plastic shell. The Journal of Acoustical Science and Technology, 30(6), 2009, pp. 410–416.

[4] Siswanto, W.A., Tam, L., Kasron, M.Z. Sound Characteristics and Sound Prediction of the Traditional Musical Instrument the Three-Rattle Angklung International Journal of Acoustics and Vibration, 17(3), 2012, pp. 120-126.

[5] Karjalainen, M., Backman, J., Polkki, J. Analysis, Modeling, and Real-time Sound Synthesis of the Kantele, a Traditional Finnish String Instrument. Proceedings of the 1993 IEEE International Conference on Acoustics, Speech, and Signal Processing: Plenary, Special, Audio, Underwater Acoustics, VLSI, Neural Networks - Volume I. Washington, DC: IEEE Computer Society, 1993, pp. 229-232.

[6] Chaigne, A., Touzé, C., Thomas, O. Nonlinear vibrations and chaos in gongs and cymbals Acoustical science and technology, Acoustical Society of Japan, 26, 2005, pp. 403-409.

[7] Rhaouti, L., Chaigne A., Joly, P. Time-domain modeling and numerical simulation of a kettledrum. The Journal of Acoustical Society of America, 105(6), 1999, pp. 3545–3562.

[8] Rossing, T.D., Bork, I., Zhao, H., Fystrom, D.O. Acoustics of snare drums, The Journal of Acoustical Society of America, 92(1), 1992, pp. 84 – 94.

[9] Avanzini, F., Marogna, R. A modular physically based approach to the sound synthesis of membrane percussion instruments, The Journal of Audio, Speech, and Language Processing, IEEE Transactions on, 18(4), 2010, pp. 891 – 902.

[10] Siswanto, W.A., Che Wahab, W.M.A., Yahya, M.N., Ismail A.E., Nawi, I. A platform for digital reproduction sound of traditional musical instrument Kompang, Applied Mechanics and Materials, 660, 2014, pp. 823-827.

[11] Fletcher, N., Rossing, T. The physics of musical instruments, Springer Science & Business Media, (2012).

[12] Baricz, Generalized Bessel functions of the first kind, Springer, (2010).

[13] Golzari S., Doraisamy S., Sulaiman M.N.B., Udzir N.I., Norowi N.M., Artificial Immune Recognition System with Nonlinear Resource Allocation Method and Application to Traditional Malay Music Genre Classification. In: Bentley P.J., Lee D., Jung S. (eds) Artificial Immune Systems. ICARIS 2008. Lecture Notes in Computer Science, 5132., 2006, pp. 384 – 389.

[14] Bilbao S., Webb, C. Timpani drum synthesis in 3D on GPGPUs, Proc. of the 15th Int. Conference on Digital Audio Effects (DAFx-12), York, United Kingdom, (2012)

[15] Sugita, I.K.G., Soekrisno, R., Miasa, I.M., Suyitno, The Effect of Annealing Temperature on Damping Capacity of the Bronze 20%Sn Alloy, International Journal of Mechanical & Mechatronics Engineering, 11(04), 2011, pp. 1-5.

[16] Kuswanto, H., Comparison Study of Saron Ricik Instruments' Sound Color (Timbre) on the Gamelans of Nagawilaga and Gunturmadu from Karaton Ngayogyakarta, International Journal of Basic & Applied Sciences, 11(04), 2011, pp. 23-29.

[17] Sugita, I.K.G., Soekrisno, R., Miasa, I.M., Suyitno, Mechanical and Damping Properties of Silicon Bronze Alloys for Music Applications, International Journal of Engineering & Technology, 11(06), 2011, pp. 81-85.

[18] Siswanto, W.A., Abullah, M.S., Demonstration of Comparison between Goat Skin and X-Ray Film Membranes on Traditional Musical Instrument Kompang, Pertanika Journal of Science and Technology, 26(2), 2018, pp. 585-598