Comparison of Ultrasonic And Acoustic Sound Treatments on Grey Oyster Mushroom (Pleurotus Sajor-caju) Cultivated on Sawdust And Kenaf Waste

Mazlin Nur Iman Binti Hasnoel Mazidi, Roshita Ibrahim, Tan Soon Teck

1Department of Chemical Engineering Technology, Faculty of Engineering, UniCITI Alam Campus, Universiti Malaysia Perlis (UniMAP), 02100 Sungai Churuh, Padang Besar, Perlis

Email: mazlinuriman95@gmail.com

Abstract. Sound stimulation and substrate are among the main factors that enhance the formation of fruiting bodies in order to increase the productivity of grey oyster mushroom. The main purpose of this study is to investigate the effects of ultrasonic and acoustics sound treatments on grey oyster mushroom (Pleurotus Sajor-caju) cultivated on rubber tree sawdust and kenaf waste. The growth performance, yield and post-harvest quality of grey oyster mushroom were determined. Mushroom bags were treated with ultrasonic and acoustic sound every 5 days intervals during mycelia growth. Sound treated mushroom bags had faster growth rate and treatment with acoustic sound appeared to be a better treatment among all the treatments. In terms of yield, sawdust obtained a relatively higher amount of total weight of fruiting bodies, greater biological efficiency and bigger number of fruiting bodies than kenaf waste. Acoustic sound contributed to a higher in yield but has the highest substrate utilization among all treatments. Sawdust shows no significant different (p>0.05) in physical characteristics such as pileus diameter compared to kenaf waste but both of them showed significant different (p<0.05) among different treatments. Acoustic sound had firmer and showed relatively darker compared to other treatments. Substrate of sawdust had a relatively higher of moisture content of pileus and stem than kenaf waste. Among all the treatments used, mushroom bag treated with acoustic and cultivated on sawdust was the best treatment due to is relatively faster growth performance and higher yield.

1. Introduction

Grey oyster mushroom or Pleurotus sajor-caju is one of the edible mushrooms from Pleurotus family. They contain high nutritional contents which essential to human body such as digestible protein, minerals, vitamins, carbohydrates and fibre [1]. In Malaysia, rubber tree sawdust is the main source of substrate for growing oyster mushroom [2]. Kenaf (Hibiscus cannabinus) is the third largest crop, after wood and bamboo, and has become a new renewable source of industrial purpose in developed countries [3]. Acoustics is a sound that can be heard by human. Ultrasonic sound is a sound which our human normally cannot hear. Nowadays, the commercial mushrooms producers in Malaysia are facing major problem in term of fulfilling the high domestic demand of mushrooms. Agriculture activities produce a lot of lignocellulose wastes such kenaf waste as which causes pollution by open burning and contribute to the greenhouse effect.

To whom any correspondence should be addressed.
The main purpose of this study is to compare ultrasonic and acoustic sound treatments on grey oyster mushroom (*Pleurotus sajor-caju*) cultivated on rubber tree sawdust and kenaf waste.

2. Materials and methods
This study utilized rubber sawdust and kenaf core fiber waste as the main substrate for mushroom cultivation. A ratio of 1:10:100 was used for calcium carbonate, rice bran and sawdust or kenaf respectively. After that, polyethylene bags was used to fill up with around 500g of the mixture of substrate. The neck was placed at the end of the bag and closed up with plastic cap which was inserted with cotton within the cap. Five replicates of polyethylene bags were used for each treatment. The bags were then be transferred to sterile at 121℃ for 30 minutes by using autoclave. The mushroom bags were cooled overnight after sterilization and ready to be inoculated with grey oyster mushroom species. Substrate was inoculated with mycelium through the use of mushroom spawn. Spawn is just a smaller amount of a nutritious material upon which the mycelium can begin to grow before it is ready to colonize a substrate.

2.1. Ultrasonic or Acoustic Sound Treatment on Different Substrates
After 5 days of inoculation, the length of mycelium travelling down the mushroom bags were measured before each of them was treated with ultrasonic or acoustic sound treatment on the different substrate. This treatment was done every 5 days interval. The untreated mushroom bags were served as control. The ultrasonic sound treatment was conducted at 37000Hz by using ultrasonic bath for 1.5 minutes while acoustic sound treatment was carried out at 75 decibel intensity by using firecracker sound for 1.5 minutes. During ultrasonic sound treatment, mushroom bags were put in a low light intensity room and covered with a plastic bag (prevent water leaking). While acoustic sound treatment was treated by using a speaker (sound set at 75 decibel and tested) with a 3 meter range (measure by ruler) away with mushroom bags.

2.2 Spawning Stage
Two stages which involved in the mushroom growth process were spawning stage and fruiting body formation. The mycelium growth stage also known as spawning stage. In this stage, the mushroom bags were arranged vertically which helped to accelerate the spawn process. For spawning process to proceed more effectively, some parameters were controlled such as the optimum temperature for the mushroom bags were kept at 28℃ to 30℃, the surrounding humidity was maintained at 80% to 85% and about 15% of low light intensity was required.

2.3 Mushroom Growth Process and Harvesting
Once the mycelium had fully colonized, the mushroom bags were transferred to the mushroom house. Then, the caps were opened and the mushroom bags were placed horizontally on the racks in order for pinhead emergence and fruiting body formation. During pinhead emergence and fruiting body formation, more light intensity and relative humidity were needed compared to during spawning process. The temperature was in between 25℃ and 30℃, with relative humidity of 80% to 85% and light intensity was about 15%. The matured fruiting bodies which appeared as grey oyster shape of mushrooms were then harvested. After that, the caps were used again to close up the mushroom bags and left for 7 days for the next fruiting cycle in order to enable the tissue of mycelium to recover from injury.

2.4 Mycelium Growth Rate
The mycelium growth rate was defined as the length of the mycelia in the colonized culture bag divided by the incubation time. Mycelium growth rate which was treated with ultrasonic or acoustic sounds on sawdust and kenaf waste substrates were measured by using ruler in unit of cm per day at every five days interval.
2.5 Growth Performance
The mycelium growth performance was observed when the pinhead emerged. The substrate surfaces were fully covered by the mycelium and the cap was opened to enable the formation of fruiting bodies with 80% to 85% percentage of humidity. The pinhead emergence and fruiting body formation took about 27 and 34 days to matured after inoculation and spawning process respectively.

2.6 Yield Analyses
Grey oyster mushroom was harvested from the substrate bags once the pinhead and fruiting bodies were matured. Then, yield analyses were measured and recorded in terms of total fresh weight of fruiting bodies, number of fruiting bodies and percentage of biological efficiency.

2.7 Pileus Diameter
The fresh grey oyster mushroom was harvested from the different substrates of ultrasonic or acoustic sound treatments and control. Diameter of the largest and smallest size pileus were measured by using ruler.

2.8 Texture (firmness) Determination
To test the firmness of harvested grey oyster mushroom, Texture Analyser TA.XT plus (Stable Micro Systems) was used by using P/2 stainless steel probe. The grey oyster mushroom pileus was placed on the stage of the texture analyser. Three different points were taken from the same surface of the harvested grey oyster mushroom to analyse the firmness. In the penetration test, cylinder probe of 2 mm diameter was used to puncture the harvested grey oyster mushroom pileus from top to 5 mm depth. During the analysis process, the texture profile of penetration showed the force, distance and time taken for grey oyster mushroom pileus. Then, the maximum positive firmness values was recorded.

2.9 Pileus Colour
The physical analysis of colour was applied on the cap (pileus) of grey oyster mushroom using a Minolta Chromameter. About three points of the same mushroom pileus were selected for the colour analysis. L*, a* and b* value was achieved from the display of chromameter. L* value indicated lightness (0 = black, 100 = white), a* value was indicated colour on a green (-) to red (+) axis and b* value indicated chromaticity on a blue (-) to yellow (+) axis [4].

2.10 Moisture Content
Using moisture analyser AND MX-50, the fresh weight of harvested grey oyster mushroom was weighed and placed on the pan at 105°C for about one an hour. The moisture content of grey oyster mushroom was determined.

2.11 Experimental Design and Statistical Analysis
The experiment was designed based on Completely Randomized Design (CRD) with ultrasonic and acoustic sound treatment of rubber sawdust and kenaf core fiber substrates. All the data obtained were analysed using two way Analysis of Variance (ANOVA), considering significant at (P<0.05) using Tukey’s Studentized Range test. Each treatment was done in five replicates. The statistical software was used Statistical Analysis System (SAS) version 16.0 software.

3. Results and Discussion
This parts discusses the results obtained effects of ultrasonic and acoustic sound treatments on growth performance, yield biological efficiency, and physico-chemical properties of harvested grey oyster mushroom cultivated on sawdust and kenaf waste.
3.1 Mycelium Growth Rate

The mycelium growth of *Pleurotus sajor-caju* subjected to ultrasonic and acoustic sound treatments cultivated on sawdust and kenaf waste is shown in Figure 1 and Table 1. The mushroom bags were standardized to 23.5 cm length and 7 cm diameter. From Figure 1, mushroom bag with ultrasonic sound treatment cultivated on sawdust had the fastest time for mycelium to reach 23.5 cm followed by acoustic treatment where control (no sound treatment) took the longest period to reach 23.5 cm.

![Figure 1. The mycelium growth of *Pleurotus sajor-caju* subjected to different durations of ultrasonic treatment. Vertical bars represent standard errors.](image)

The mycelium growth rate in cm per day for different sound treatments on different substrates presented in Table 1. On sawdust substrate, there were significant differences (P<0.05) in mycelium growth rate among different sound treatments where sound treated bags showed significantly higher (P<0.05) mycelium growth rate compared to control. However, no significant different (P>0.05) was obtained between ultrasonic and acoustic treatments. Similar to sawdust, substrate of kenaf waste also showed that sound treated bags had significantly higher (P<0.05) growth rate than control, and there was also no significant different (P>0.05) between ultrasonic and acoustic treatments. For all the sawdust, ultrasonic sound treated bags had (0.822 cm/day) the highest mycelium growth rate, followed by acoustic (0.800 cm/day) and the slowest was control (0.740 cm/day). For the kenaf treated bags, the highest rate for mycelium to grow is acoustic bags (0.740 cm/day), followed by ultrasonic bags (0.739 cm/day) and the control bags (0.691 cm/day) took the longest period. It showed that all the ultrasonic and acoustic sound treated bags had significantly higher rate of mycelium growth compared to control as also complemented with study done by [5]. According to [4], the best substrates for cultivating oyster mushroom are sawdust and sugarcane bagasse compared to other agricultural-based substrates.
Table 1. The means of mycelium growth rate (cm/day) of Pleurotus sajor-caju subjected to different sound treatments (ultrasonic and acoustic) and substrates (sawdust and kenaf waste).

| Treatment Substrate | Sound | Control | Ultrasonic | Acoustic |
|---------------------|-------|---------|------------|----------|
| Mycelium Growth Rate (cm/day) |       |         |            |          |
| Sawdust             | 0.740 ± 0.029<sup>A</sup><sub>b</sub> | 0.822 ± 0.027<sup>A</sup><sub>a</sub> | 0.800 ± 0.015<sup>A</sup><sub>a</sub> |          |
| Kenaf               | 0.691 ± 0.014<sup>B</sup><sub>b</sub> | 0.739 ± 0.019<sup>B</sup><sub>a</sub> | 0.740 ± 0.025<sup>B</sup><sub>a</sub> |          |

Note: Values are means of 5 replicates. Means (n=5) ± standard deviation.

a-c: Values bearing the different superscript within the same column are significantly different at 5% level (P<0.05).

3.2 The Number of Days for Mycelium to Fill-up the Bag, Pinhead Emergence and Fruiting Body Formation

Figure 2 shows that there were significant differences (P<0.05) in the number of days taken for mycelium to fill-up the mushroom bags among the different sound treatments on different substrates. Sawdust took a significantly shorter (P<0.05) time for mycelium to fill-up mushroom bags than kenaf. All sound treated bags cultivated on sawdust and kenaf took a significantly shorter (P<0.05) time for mycelium to fill-up compared to all untreated bags. Nevertheless, there were no significant different (P>0.05) between ultrasonic and acoustic treatment.

Meanwhile, on sawdust substrate, control took the longest period (31.8 days) compared to acoustic (29.40 days) and ultrasonic treatment (28.60 days). While for kenaf waste, acoustic and ultrasonic treatment (31.80 days) took the same period and the longest period was also control (34.00 days). A study reported that the treatment using sound waves can accelerate the rate of mycelium growth by 15% [4].
According to Figure 2, there was significant different (P<0.05) for pinhead emergence between the two different substrates where among the different sound treatments showed no significant differences (P>0.05) for pinhead emergence. Between the two substrates, kenaf took a significantly longer period than sawdust. For sawdust, acoustic treated bags took only 2.6 days, followed by ultrasonic (3.8 days) and the longest period was control (7.6 days). Meanwhile, on kenaf, shortest period was acoustic (18.6 days), second was ultrasonic (22.6 days) and lastly the most time-consuming control (30.6 days). After the stage of pinhead emergence was fruiting body formation which the grey oyster mushroom was harvested once the mushroom matured. There was no significant different (P>0.05) in fruiting body formation among the different substrates. Furthermore, different sound treatments revealed that no significant differences (P<0.05) were observed in the number of days required for fruiting body formation. The mean period recorded for sawdust was in the range 1.6 to 2.0 days while kenaf was 1.8 to 2.0 days. A study reported that grey oyster mushroom (*Pleurotus sajor-caju*) took 1 to 4 days for formation of fruiting bodies [3].

3.3 Yield

3.3.1 Number of Fruiting Bodies
Considering the different substrates, there were significant differences (P<0.05) in the number of fruiting bodies among the different sound treatments for grey oyster mushroom where sawdust yielded from 18.5 to 45 and kenaf yielded from 13.8 to 24.9. Among all treatments, acoustic treatment was significantly higher (P<0.05) as compared to control and ultrasonic treatment. The highest number of fruiting bodies cultivated on sawdust is acoustic (45.0) treated bags then is control (33.0) and the lowest is ultrasonic (18.5) sound. For kenaf substrate, acoustic (24.9) is the highest, then is ultrasonic (15.6) while the lowest number of fruiting bodies is control (13.8). The food quality was found to be increased and the yield of plants also increased by 6 to 14% when they are applied with sound treatment. The rise in plant growth characteristics is due to the increased reactivity of biological substances in the seeds under the influence of sound treatment. The similar results were also observed where the number of fruiting bodies for all sound treated bags were greater than control [1].

### Table 2. The number of fruiting bodies, total weight of fruiting bodies and biological efficiency of *Pleurotus sajor-caju* subjected to different sound treatments (ultrasonic and acoustic) and substrates (sawdust and kenaf waste).

| Sound Treatment | Substrates | Control          | Ultrasonic       | Acoustic         |
|-----------------|------------|------------------|------------------|------------------|
|                 | No. of fruiting bodies | 33.0 ± 14.30<sup>Ab</sup> | 18.5 ± 7.83<sup>Ab</sup> | 45.0 ± 14.90<sup>Aa</sup> |
|                 | Sawdust    | 13.8 ± 5.75<sup>Ab</sup> | 15.6 ± 4.45<sup>Aab</sup> | 24.9 ± 6.50<sup>Ba</sup> |
|                 | Kenaf      | 291.00 ± 89.03<sup>Ab</sup> | 308.50 ± 64.48<sup>Aa</sup> | 382.50 ± 58.18<sup>Aa</sup> |
|                 | Total weight of fruiting bodies (g) | 119.40 ± 9.22<sup>Bb</sup> | 174.90 ± 15.79<sup>Ba</sup> | 159.60 ± 25.60<sup>Ba</sup> |
| Biological efficiency (%) | 58.20 ± 17.81<sup>Aa</sup> | 61.70 ± 12.90<sup>Aa</sup> | 76.50 ± 11.64<sup>Aa</sup> |
|                 | Sawdust    | 44.72 ± 3.45<sup>Ab</sup> | 65.51 ± 5.91<sup>Aa</sup> | 59.78 ± 9.59<sup>Ba</sup> |
|                 | Kenaf      | Note: Values are means of 5 replicates. Means (n=5) ± standard deviation A-B : Values bearing the same superscript within the same column are not significant at
3.3.2 Total Weight of Fruiting Bodies. Statistically, substrates of sawdust took a significantly higher (P<0.05) in total weight of fruiting bodies than kenaf. The average weight for sawdust ranged from 291.00 g to 382.50 g but average weight for kenaf only from 119.40 g to 174.90 g. Among the different sound treatments, acoustic treatment showed significantly higher (P<0.05) compared to control and ultrasonic. The highest weight of fruiting bodies was acoustic sawdust (382.50 g), followed by ultrasonic sawdust (308.50 g), control sawdust (291.00 g), acoustic kenaf (174.90 g), ultrasonic kenaf (159.60 g) and control kenaf (119.40 g) was the lowest. The range of individual yields observed for different substrates with different sound treatments were varied, resulting in a high standard deviation which shown in Table 2. This variation was likely due to contaminants or climatic variation within the mushrooms house [6].

3.3.3 Percentage of Biological Efficiency. From Table 2, there was significant different (P<0.05) obtained in biological efficiency among the different substrates. Sawdust took a significantly higher than substrate of kenaf. Moreover, on kenaf, there were significant differences (P<0.05) observed among different sound treatments where control showed a significantly lower (P<0.05) in biological efficiency compared to ultrasonic and acoustic. However, there were no significant differences (P>0.05) obtained among different sound treatments on substrate of sawdust. The result showed that the highest biological efficiency was acoustic (76.50%) cultivated on sawdust, followed by ultrasonic (61.70%) and lowest was control (58.20%). Meanwhile, on kenaf, ultrasonic was the highest (65.51%), followed by acoustic (59.78%) while the lowest biological efficiency was control (44.72%). The addition of sound treatment for mushroom bags may be beneficial as it act as the environment stress to promote growth and yield of mushrooms. Studies done by [5] investigated that the higher biological efficiency and yield of mushroom correspond to the mycelium growth, period of colonization and duration to harvest.

3.4 Pileus Size
The pileus size of *Pleurotus sajor-caju* was determined by pileus diameter while the pileus diameter was measured from two ended side points of the mushroom’s pileus. Judging from Figure 4.7, it shows that the smallest and largest of pileus size of *Pleurotus sajor-caju*. There was no significant different (P>0.05) found in the smallest pileus diameter between the sawdust and kenaf. (Table 3). On sawdust, ultrasonic treatment took a significantly larger (P<0.05) in smallest pileus diameter than control and acoustic treatments. However, there were significant differences (P<0.05) obtained in smallest pileus diameter among all treatments where no significant different (P>0.05) between ultrasonic and acoustic treatment. Among all the treatments, ultrasonic was the longest length (ranged from 8.32 cm to 9.96 cm), followed by acoustic (ranged from 6.45 cm to 7.36 cm) and control (2.46 cm to 3.04 cm) was the shortest in smallest pileus diameter. In the case of largest pileus diameter, there was no significant different (P>0.05) between the two substrates. Meanwhile, ultrasonic treatment took a significantly higher (P<0.05) in largest pileus diameter compared to control and acoustic treatment. The longest length in largest pileus diameter was ultrasonic treatment, 11.78 cm and 11.32 cm, followed by acoustic treatment, 10.4 cm and 9.77 cm while 7.65 cm and 8.18 cm was the shortest length for control.
Table 3. The pileus diameter (cm) subjected to different sound treatments (ultrasonic and acoustic) and substrates (sawdust and kenaf waste).

| Sound Treatment | Control       | Ultrasonic    | Acoustic     |
|-----------------|---------------|---------------|--------------|
| Smallest Pileus Diameter (cm) |               |               |              |
| Sawdust         | 2.46 ± 0.246\textsuperscript{Ac} | 8.32 ± 1.238\textsuperscript{Aa} | 6.45 ± 1.236\textsuperscript{Ab} |
| Kenaf           | 3.04 ± 1.159\textsuperscript{Ab} | 9.96 ± 2.704\textsuperscript{Aa} | 7.36 ± 2.001\textsuperscript{Aa} |
| Largest Pileus Diameter (cm) |               |               |              |
| Sawdust         | 7.65 ± 0.617\textsuperscript{Ab} | 11.32 ± 0.842\textsuperscript{Aa} | 10.4 ± 0.623\textsuperscript{Aa} |
| Kenaf           | 8.18 ± 0.971\textsuperscript{Ab} | 11.78 ± 1.233\textsuperscript{Aa} | 9.77 ± 0.618\textsuperscript{Ab} |

Note: Values are means of 5 replicates. Means (n=5) ± standard deviation
A-B : Values bearing the same superscript within the same column are not significant at 5% level (P<0.05)
a-c : Values bearing the same superscript within the same row are not significant at 5% level (P<0.05)

3.5 Colour

From the data recorded and presented in the Table 4, it shows significant differences (P<0.05) in terms of colour L\* value between sawdust and kenaf. The colour L\* value were expected be close to the two substrates because the harvested mushroom included \textit{Pleurotus sajor-caju} only. Kenaf showed significantly higher than sawdust for control and ultrasonic treatment except for acoustic treatment. The value cultivated on sawdust were in the range from 57.35 to 69.03 while on kenaf, the average values were between 61.06 and 70.75. When under high temperature and high humidity, the pileus of grey oyster mushroom tends to become brownish grey [5]. Nevertheless, it can be seen that there were significant differences (P<0.05) among the different sound treatments where no significant different (P>0.05) obtained between control and ultrasonic treatment. This might be the high stresses produced by sonicator bath (ultrasonic sound) and speaker (acoustic sound) to mushroom bags. The highest value was control kenaf (70.75), followed by ultrasonic kenaf (69.14), acoustic sawdust (69.03), acoustic kenaf (61.06), control sawdust and lowest was ultrasonic sawdust (57.35).

Table 4. The colour (L\*, a\*, and b\* values) of \textit{Pleurotus sajor-caju} subjected to different sound treatments (ultrasonic and acoustic) and substrates (sawdust and kenaf waste).

| Sound Treatment | Control       | Ultrasonic    | Acoustic     |
|-----------------|---------------|---------------|--------------|
| Colour L\* value |               |               |              |
| Sawdust         | 57.99 ± 3.794\textsuperscript{Bb} | 57.35 ± 3.198\textsuperscript{Bb} | 69.03 ± 6.001\textsuperscript{Ab} |
| Kenaf           | 70.75 ± 4.321\textsuperscript{Aa} | 69.14 ± 3.702\textsuperscript{Aa} | 61.06 ± 2.708\textsuperscript{Bb} |
| Colour a\* value |               |               |              |
| Sawdust         | 5.59 ± 0.436\textsuperscript{Aa} | 5.49 ± 0.113\textsuperscript{Aa} | 4.59 ± 0.351\textsuperscript{Ab} |
In case of colour a* value, there was significant different (P<0.05) between the two substrates. Excluded acoustic treatment, kenaf took a significantly lower (P<0.05) in colour a* value on control and ultrasonic treatment. Even though colour a* value for sawdust and kenaf were very close to each other. Nonetheless, the value of colour a* shows in the Table 4 display a major difference (P<0.05) among different sound treatments for each of the substrate. But there was no significant different (P>0.05) between control and ultrasonic. On sawdust, highest colour a* value was control (5.59), followed by ultrasonic (5.49) and acoustic (4.59). For kenaf, acoustic was the highest (4.47) while control and ultrasonic had the same value (3.85). These values point out the colour presence of more redness in the pileus. Meanwhile, sawdust display significantly higher (P<0.05) in colour b* value than kenaf on acoustic treatment but no significant different (P>0.05) obtained between the two substrates. Even though the value of firmness for sawdust (ranged from 58.90 gF to 61.64 gF) and kenaf (60.24 gF to 68.49 gF) were very close to each other. This might probably due to mushroom cultivated on sawdust has thicker and smaller diameter of pileus in which the tissues in the pileus are more compactly held together compared to kenaf waste. The texture of grey oyster mushroom generally indicated significant variability (P<0.05) among the different treatments where no critical different (P<0.05) obtained on control and ultrasonic treatment. The highest value of firmness was acoustic kenaf (68.49 gF), followed by acoustic sawdust (61.64 gF), ultrasonic sawdust (61.51 gF), control sawdust (61.48 gF) and the lowest was control kenaf (60.24 gF).

3.7. Moisture Content
According to Table 5, there was significant different (P<0.05) was observed in the pileus moisture content among the two substrates. Sawdust (around 90.5%) had significantly higher in pileus moisture content than kenaf (around 87%). Meanwhile, no significant differences (P<0.05) were obtained among the different treatments. The percentage of pileus moisture content for the control (90.337%
and 87.13%), ultrasonic (90.203% and 87.40%) and acoustic sound treatment (90.503% and 86.13%) which cultivated on sawdust and kenaf are very near to each other.

Table 5. The moisture content (Pileus and Stem) of *Pleurotus sajor-caju* subjected to different sound treatments (ultrasonic and acoustic) and substrates (sawdust and kenaf waste).

| Sound Treatment | Control          | Ultrasonic        | Acoustic         |
|-----------------|------------------|-------------------|------------------|
| Substrates      | Pileus Moisture Content (%) | Pileus Moisture Content (%) | Pileus Moisture Content (%) |
| Sawdust         | 90.337 ± 0.194<sup>Aa</sup> | 90.203 ± 0.085<sup>Aa</sup> | 90.503 ± 0.205<sup>Aa</sup> |
| Kenaf           | 87.13 ± 0.494<sup>Ba</sup> | 87.40 ± 1.377<sup>Ba</sup> | 86.13 ± 0.678<sup>Ba</sup> |
| Stem Moisture Content (%) | | | |
| Sawdust         | 81.797 ± 1.67<sup>Aa</sup> | 73.077 ± 2.025<sup>Ab</sup> | 79.943 ± 2.866<sup>Aa</sup> |
| Kenaf           | 67.603 ± 0.692<sup>Bb</sup> | 69.397 ± 1.103<sup>Ab</sup> | 70.993 ± 0.214<sup>Ba</sup> |

Note: Values are means of 5 replicates. Means (n=5) ± standard deviation
A-B : Values bearing the same superscript within the same column are not significant at 5% level (P<0.05)
a-c : Values bearing the same superscript within the same row are not significant at 5% level (P<0.05)

4. Conclusion
The study was carried out basically to investigate the effects of ultrasonic and acoustic sound treatments on grey oyster mushroom (*Pleurotus sajor-caju*) cultivated on sawdust and kenaf waste. There were significant differences (P<0.05) in terms of yield (number of fruiting bodies, total weight of fruiting bodies and biological efficiency) between two substrates among different sound treatments. Substrate on sawdust gained a significantly higher number of fruiting bodies, total weight of fruiting bodies and biological efficiency compared to kenaf waste. Meanwhile, mushroom bags treated with sound treatments mostly obtained a greater yield compared to control which mushrooms was treated under sound ranges between 20 Hz and 20 KHz for acoustic and over 20 KHz for ultrasonic. Acoustic sound conduced to relatively higher yield for both substrates of grey oyster mushroom and also used lesser in substrate utilization efficiency among all sound treatments. Furthermore, no significant variability (P>0.05) exerted in the pileus diameter between the two substrates. The largest and smallest pileus diameter of grey oyster mushroom shows significant differences (P<0.05) among all different treatments. This indicates that grey oyster mushroom is more on sound treatments in the growth development of pileus diameter. Acoustic obtained the largest size in smallest and largest pileus diameter compared to control and ultrasonic sound. In terms of postharvest quality, there were significant differences (P<0.05) in colour and texture between two substrates among all treatments. Even though only one species of oyster mushroom was used. Statistically, both pileus and stem moisture content shows significant differences (P<0.05) for sawdust and kenaf waste although the percentages of moisture content were very near among all treatments. Mushroom bags cultivated on sawdust familiarly have higher growth rate performance than substrate of kenaf waste. In terms of sound treatments, sound treated bags generally have faster rate of growth performance compared to those untreated bags which name as control. This is because sound is one of the environmental circumstances that is crucial for mushroom initiation and fruiting development. Acoustic sound seem to be the most potential for growth performance of grey oyster mushroom.
References
[1] Bahri S S, and Rosli I W W 2017 Intern Food Res J, 24(4) 1445.
[2] Kim B S 2004 Mushroom Grower’s Handbook 1 01 192–196.
[3] Firdaus S M, Bahri A R S, Rahijan M and Rahman A W A 2015 Adv in Life Sci and Tech 28 51–60.
[4] Ibrahim R, Azmil A, Mohd I, Hasan S M Z and Arshad A M 2017 AIP Conf. Proceed 01054.
[5] Ibrahim R, Yasin N F L, Arshad A M, and Hasan S M Z S 2015 Malay Appl Bio 44(1) 75–82.
[6] Tisdale T E 2004 University of Hawaii at Manoa Articles 13.

Acknowledgment
The authors would like to express their gratitude to the financial support provided by the Ministry of Higher Education Malaysia through Fundamental Research Grant Scheme (FRGS/1/2016/WAB01/UNIMAP/03/5) and all the staffs in Dept. of Chem. Eng. Tech., Faculty of Engineering Technology (FETech) and Institute of Sustainable Agrotechnology (INSAT) of Universiti Malaysia Perlis.