A PRELIMINARY STUDY OF EFFECTS OF AUDIBLE SOUND ENERGY TO MICROORGANISMS

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ABSTRACT

This preliminary study is to determine the effect and the effectiveness of an alternative energy such as audible sound energy in affecting the level of contamination in industry products that dealing with microorganism by looking at the growth of microbes in pasteurized milk. The audible sounds that were used in this preliminary study are frequency of 20 Hz, 200 Hz, 2000 Hz, 20000 Hz, white noise and pink noise. Three pasteurized milk samples which are then taken to sound treatment for 2 hours are prepared with one of them under controlled. After count the colonies of microbes from milk samples that growth in the culture media prepared before, data analysis had been done by using SPSS 11.5 for Windows software. Based on the result from data analyzed, it can be conclude that, there is an effect of audible sound on microorganisms in the pasteurized milk. Frequency of 20 Hz and 200 Hz would increase the growth of microbes in milk, meaning that it would increase the level of contamination in pasteurized milk. While white noise, pink noise, frequency of 2000 Hz and 20000 Hz would decrease the growth of milk microbes. The most effective audible sound in reducing the growth rate of microbes in milk is frequency of 20000 Hz, while the most effective audible sound in increasing the growth of microbes in milk is frequency of 200 Hz.

KAJIAN AWALAN BAGI KESAN BUNYI YANG DAPAT DIDENGAR TERHADAP MIKROORGANISMA

ABSTRAK

Kajian awalan ini adalah untuk menentukan kesan dan keberkesanan suatu tenaga alternatif seperti tenaga bunyi yang boleh didengar dalam mempengaruhi peringkat kontaminasi dalam suatu produk industri yang melibatkan mikroorganisma dengan memerhatikan tumbesaran mikroorganisma dalam susu Pasteur. Bunyi yang boleh didengar yang digunakan dalam kajian awalan ini ialah bunyi yang berfrekuensi 20 Hz, 200 Hz, 2000 Hz, dan 20000 Hz serta hingaran (ataupun kebisingan) putih dan hingaran merah-muda. Terdapat tiga sample susu Pasteur yang kemudiannya perlu didedahkan kepada bunyi yang boleh didengar selama 2 jam telah disediakan dengan salah satu daripadanya adalah di bawah kawalan. Selepas mengira bilangan koloni yang tumbuh dalam media kultur yang telah disediakan sebelum itu, analisis data dilakukan dengan menggunakan perisian SPSS 11.0 untuk Windows. Berdasarkan kepada keputusan yang dianalisis, maka boleh disimpulkan bahawa, terdapat kesan bunyi yang boleh didengar terhadap mikroorganisma dalam susu Pasteur. Frekuensi 20 Hz dan 200 Hz akan meningkatkan peringkat kontaminasi dalam susu Pasteur. Manakala bagi hingaran putih, hingaran merah-muda, frekuensi 2000 Hz dan 20000 Hz pula akan mengurangkan kadar tumbesaran bagi mikrob dalam susu. Bunyi yang boleh didengar yang paling berkesan dalam mengurangkan kadar tumbesaran mikrob dalam susu ialah bunyi yang berfrekuensi 20000 Hz, manakala bunyi yang boleh didengar yang paling berkesan dalam meningkatkan kadar tumbesaran mikrob dalam susu ialah bunyi yang berfrekuensi 200 Hz.

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FIGURE LIST

SYMBOL LIST

Hz	hertz
kHz	kilohertz
MHz	megahertz
μ	micro
μm	micrometer
mm	millimeter
m	meter
ms^{-1}	meter per second
ms^{-2}	meter per second square
υ	velocity
λ	lambda, wavelength in meter
γ	adiabatic constant
R	gas constant, 8.31 JK^{-1} $mole^{-1}$
I_o	threshold of hearing intensity
I	intensity
dB	decibel
dBA	decibel with A-weighted
SPL	sound pressure level
$\log_{10}$	logarithm to the base 10
θ	absolute temperature, in unit Kelvin, K.
°C	degree Celsius
M	molecular weight, in unit kg $mole^{-1}$
kg $mole^{-1}$	kilogram per mole
Wcm^{-2}	watt per centimeter square
f	frequency
T	time period in a second
ml	milliliter
μl	microliter
LAB	Lactic acid bacteria
c.f.u.	Colony-forming units

CHAPTER 1

PREFACE

1.1 INTRODUCTION

1.1.1 Sound Wave

Sound waves are the most important example of longitudinal waves. They can travel through any material medium with a speed that depends on the properties of the medium. There are two types of sound waves in this world; that is audible (hearable) and inaudible (non-hearable) refers to human's hearing range. Humans can normally hear sound with frequencies in the range of 20 to 20,000 Hz (20 kHz), which is called an audible range (Young & Freedman, 2004).

When a sound wave's frequency lies above 20 kHz, it is called an ultrasonic wave. While we cannot hear ultrasonic waves, we apply them in various technologies such as sonar systems, sonograms, surgical tools, and cleaning systems. Some animals also use ultrasonic waves in a specialized technique called echolocation that allows them to pinpoint objects and other animals, even in the dark (Beyer, 2002).

When a sound wave's frequency is below 20 Hz, it is called an infrasonic wave. Infrasonic waves can be generated by tidal motion, by earthquakes, and by explosive charges for use in seismology. An infrasonic wave is especially dangerous, due to its strong vibrations, or oscillations. Not much amplitude is needed to produce negative effects on the living organism, and even mild infrasound exposure requires several hours, or even days, to reverse symptoms (Leighton, 1994). So, in this project, audible sound with frequencies near infrasonic frequency range and near ultrasonic frequency range will be use as a sound treatment to the microorganism in milk.

1.1.2 Microbiology

Microbiology is the science of microorganisms, which is the science dealing with small living organisms (Latin: *micros* = small, *bios* = life, *logi* = science). Microbiology deals with organisms that are so small that they cannot be viewed with the naked eye. In order to study microorganisms (from the Greek word *micro,* meaning small) they must be enlarged, for instance by the aid of a microscope, up to one thousand times or sometimes several thousand times. Sometimes microorganisms are also called microbes (Ramstorp, 2003).

The microorganisms include viruses, bacteria, fungi, algae, and protozoa. Most bacteria are 0.5 to 2.0 μm in length (Atlas, 1995). So, a million of bacteria can fit on the tip of a pin is not impossible. Individual bacteria can only be seen under a microscope to magnify the image.

By learning about microorganisms, we will be able to understand why sometimes we suffer infections and diseases. We also will be able to see how modern medical practices attempt to control and to eliminate disease-causing microorganisms and to treat infectious disease when they occur.

At the same time you may surprise that, while the general layman's view is that all microorganisms are harmful to human health. However, most microorganisms do not cause disease. In fact, majority of them make crucial contributions to the welfare of the world's inhabitants by helping to maintain the balance of living organisms and chemicals in our environment (Tortora *et al.,* 1995). Microorganisms also have many commercial applications. They are used in the synthesis of such chemical products and in food industry such as organic acids, enzymes, alcohols, dairy products, cheese, yogurt, and many drugs.

1.2 STUDY OBJECTIVE

The purpose of this preliminary study is to determine the effectiveness of an alternative energy such as audible sound energy in affecting the level of contamination in industry products that dealing with microorganism.

In this study, there are two objectives that need to be achieved. First is to find out what will happen to the numbers of colony of microorganism in milk when audible sound energy is exposing to it, and second is to investigate the most effective audible sound that can affect the numbers of colony of microorganism in milk by assuming that the sound pressure level (SPL in dBA) for each audible sound treatment in this study would not affect the growth of microbes (to know whether there is an effect of SPL, it needs a further study).

A microorganism in milk is chosen because they have larger size in straight or curved rods shape and they can be obtaining easily from the culturing method. Besides that, milk products are quite important in our daily life. So, the study of microorganisms in milk is essentially.

1.3 RESEARCH SCOPE

To achieve the purpose and the objectives of this project, there are two major fields to study, i.e. physics of sound and microbiology's field. In physics' field, study of some characteristic of audible sound like its velocity and wavelength is very important; so that an expected data can be obtain easily. Besides that, it is essential to learn about all the devices that use to produce audible sound such as loudspeaker and function generator. In microbiology, a basic understanding of microorganism, culturing method and sterilization method is important to reduce errors and contamination that may be happen during the culturing process.

1.4 AN ANALOGY WITH QUANTUM THEORY

In 1900, when the great German physicist Max Planck (who earlier in the same year had worked out an empirical formula giving the detailed shape of the black body emission spectrum) developed the idea of quanta, energy had been thought to be a phenomenon of continuous flow - basically waves (Welch, 2004).

Quantum theory describes energy as separate, discrete "particles". An analogy that can use to explain the wave/quantum idea might be that of analog versus digital. In the analog sense, energy flows in continuous streams or waves, having no specific inherent quantity - in other words, an energy wave can be any size (Welch, 2004).

The quantum idea says energy is a "digital" flow, which what appears to be a continuous wave is actually broken down into discrete, individual "bits". The name "photon" is used for these individual energy particles. Photons contain a specific amount of energy (Welch, 2004). For example, if we have a pure red light like a laser beam, it can be thought of as a stream of photons all having a specific energy. The more photons, the brighter the light - but all the photons individually have the same amount of energy. In fact, these individual particles of energy can be detected discretely, or counted.

By using an analogy of quantum theory, how the audible sound affects the microorganisms in milk can be explain. Sound waves can be thought as photons which contain a specific amount of energy. So, when the "packets" of sound energy pass through or close to vital portions of the cell, these constitute "hits". One, or a few hits may only cause non-lethal mutations, but some of them conceivably useful. More hits are likely to cause sufficient mutations to kill or inactivate the microorganisms in the milk.

CHAPTER 2

LITERATURE REVIEW

2.1 AUDIBLE SOUND

Audible sound is produced by sound pressure that applied to a listener's ear. This pressure is initiated by a loudspeaker or some other mechanical device that creates a series of pulses of energy that, in turn, causing air molecules to vibrate. As these molecules vibrate, they bump into adjacent molecules and this would cause them to vibrate in a similar manner and "move" through the air. If these vibrations reach a listener's ear with sufficient energy to cause pressure on the eardrum, the listener "hears" an audible sound (Lerner, 1996).

Each pulse of energy contains a series of vibrations, that are sustained until the initial energy is ultimately expanded in the form of hear. Some of the vibrations cycle at a high rate while some cycle at a lower rate (i.e. high or low frequencies). If this did not happen, the listener would hear a very boring monotone which only has one frequency.

Unfortunately, listeners do not perceive all of the frequencies contained in each pulse of energy equally, because the human auditory system is not flat and its response varies with level. At low levels, its sensitivity to low frequencies is much less than its sensitivity to mid-frequencies. As level increases, the difference between low and mid-frequency is less, producing a more uniform spectral response (Ballou, 2002).

For example, consider a comparison of the ear's response at 20 Hz to that at 200 Hz. At a loudness level of 20 phons, the sound-pressure level of a 20 Hz tone must be 58 dB higher than that at 200 Hz to have the same loudness. At 50 phons loudness level, an increase of only 20 dB is required. The ear's response is somewhat flatter at high loudness levels. Loudness level is only an intermediate step to true subjective loudness, Figure 2.1.

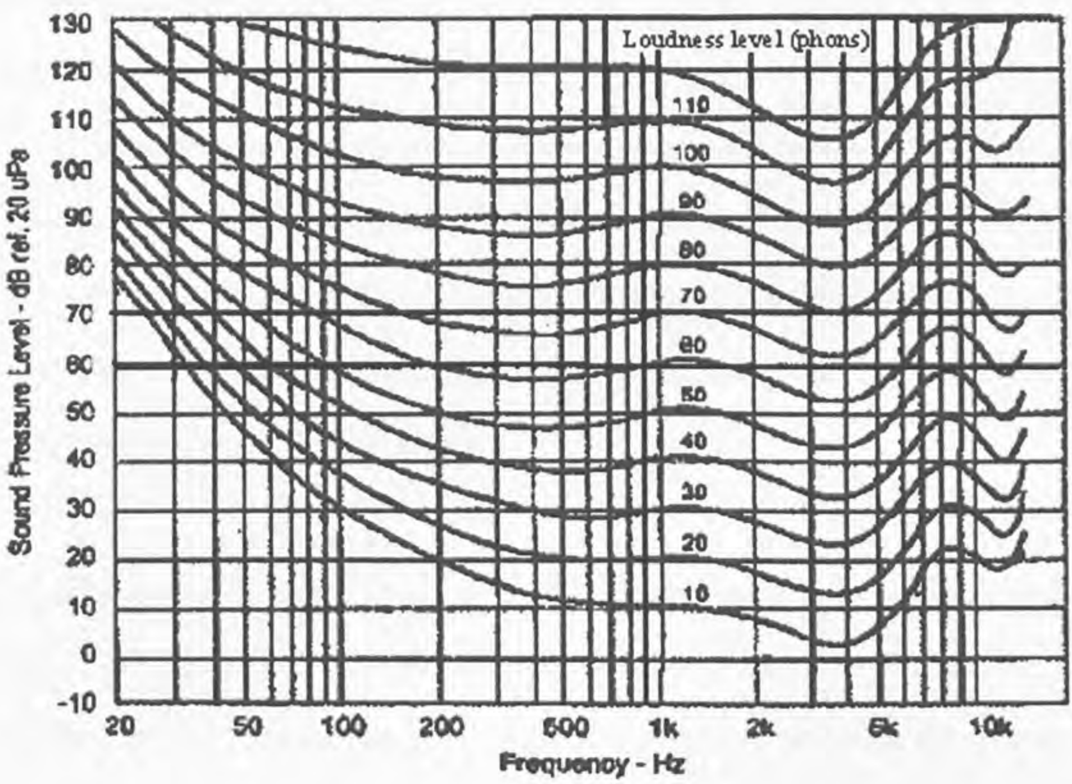

Figure 2.1 The equal-loudness contours (Ballou, 2002).

From the figure, frequencies below 50 Hz require the intensity to be increased 250,000 times to make them equal in loudness to a reference frequency of 1000 Hz. This is why bass frequencies are the most difficult to make audible, and why special speakers such as woofers and tweeters are necessary to actually produce audible low and high frequencies that can be heard by human's ear.

2.1.1 Area of Audibility

The threshold of hearing tells us that human ears are most sensitive to sound with frequency around 3 kHz (Figure2.2). At this most sensitive region, an intensity of 0 dB can just barely be heard by a person of average hearing acuity. It is instructive to know that a sound-pressure level of 60 dB turns out to be approximately 60 dB above our threshold of hearing (Everest, 1994).

The threshold of pain occurs at a sound-pressure level of about 120 or 130 dB as shown in Figure2.2. Further increase in level would results in an increase in feeling until a sensation of pain is produced. The threshold tickling is a warning that the sound which heard, is becoming dangerously loud and that ear damage is either imminent or has already taken place (Everest, 1994).

The area of audibility is in the between of the threshold of hearing and the threshold of pain. This is an area with two dimensions: the vertical dimension of sound-pressure level and the horizontal range of frequencies that the ear can perceive. All the sounds that humans can hear which is audible, must be of such a frequency and level as to fall within this area (Everest, 1994).

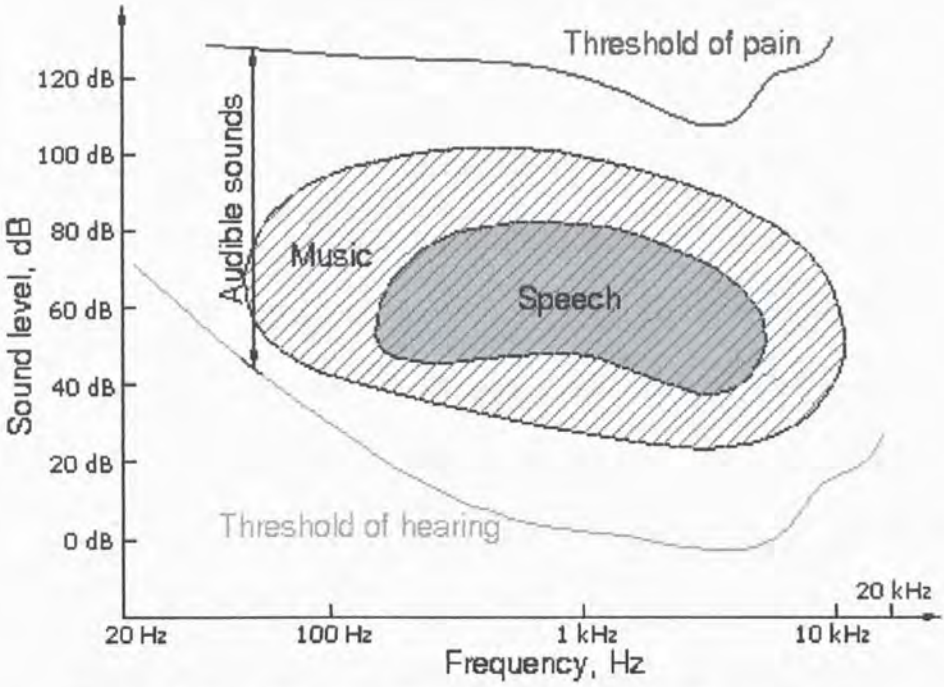

Figure 2.2 The auditory area of the human ear (Everest, 1994).

2.1.2 Frequency and Pitch

The subjective sensation of pitch corresponds to the frequency of the sound that excites the ear. Only sounds having a well-defined fundamental frequency or a fairly narrow frequency range have identifiable pitch. The sounds we call *noises* consist of a superposition of waves having a broad distribution of frequencies and do not have any particular pitch (Lerner, 1996).

When waves of very low frequency propagate through air, we feel them as vibrations. We can not "hear" them because the ear is no more sensitive than the rest of the body to low-frequency vibrations (Lerner, 1996).

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