EFFECTS OF ULTRASONIC CAVITATION ON BLOOD SAMPLES

Hydrogen Potential (pH) Value Method

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ABSTRACT

Blood is a liquid (consisting of 80%–90% of water) playing a role in the transport of food, oxygen (O_2), metabolic waste, and carbon dioxide from cells to cells of humans. The pH of the blood in the human body in a normal state is 7.35–7.45[1]). The purpose of the present study was to distinguish the pH of blood serum samples without ultrasonic versus with ultrasonic cavitation using a Piezoelectric transducer at 48 kHz, 10 Vpp, 5 Vdc, for 30 minutes. There are gaps in the current research: (1) During exercise, there are factors of endurance, fitness, and recovery with increased quality of human life; (2) Drinking is an ingredient containing sugar (carbohydrates) that adds energy and has a pH that tends to normalize the body's condition between alkaline pH (coffee, coconut water, and alkaline water) and acidic pH (*arak bali*, *ciu*, *tuak-legen*); (3) There are drinks that contain microbes (bacteria, herbal medicine, dairy milk, Yakult, sugar cane water and sugar cane water exposed to ultrasonic cavitation process using a Piezoeletric transducer). Cavitation is the decomposition of water into hydrogen (H_2) and O_2, so as to increase the pH of sugar cane water[2]). These gaps represented the basis for selecting blood samples for ultrasonic cavitation using a Piezoelectric transducer. Results showed that the average pH of blood serum without exposure to ultrasonic Piezoelectric transducer was 8.67 and the average pH of blood serum with ultrasonic exposure to ultrasonic Piezoelectric transducer was 10.

Keywords: Blood, pH, ultrasonic, Piezoelectric.

INTRODUCTION

A. Blood and exercise

Blood is a liquid found in all living things at various levels. It serves to transport processed food and drinks (carbohydrates) from the intestine and O_2 from the lungs to all cells in the organs of living things to be processed in the cells as metabolic processes that will produce energy and carbon dioxide (CO_2) as metabolic waste. Some of this waste can be reprocessed and some cannot be processed (removed) and is transported by the blood to the reprocessing organs (such as, the kidney) or the excreting organs (such as, the bladder (urine) and lungs (CO_2)). The normal blood pH at arterial blood vessels is 7.4,[3] whereas the normal blood pH at the veins is 7.35. A blood pH above 7.45 is called alkalosis and one below 7.35 is called acidosis.[1] Humans can live after drinking alcoholic drinks (pH of 2–3) or alkaline drinks (pH of 8–9), where each of these types of drinks has benefits for the human body.[4]

Research on exercise and drinks demonstrated that coffee can increase muscular strength and endurance,[5] chocolate milk can be used for recovery after ball training,[6] brown sugar can improve sport performance.[7] Oralit and coconut water can increase the levels of electrolytes in the blood in physical exercise,[8] and drinking sugar cane water before exercise is proven to improve the fitness of Badminton athletes.[9] Health research showed that ionized alkaline water can improve the quality of life of children with asthma.[10] An ultrasonic machine (Piezoelectric transducer) placed under a glass container (glass beaker, measuring cup, Erlenmeyer flask) filled with metals (mechanically irregular and immersed into a bacteria-containing solution) will vibrate the solution and bacteria in the container and kill most of the bacteria in the solution.[11] The above-mentioned ultrasonic research was developed in sugar cane water exposed to ultrasonic Piezoelectric transducer for ±3 hours, producing alkaline sugar cane water (pH = 8.5). [12] The study is in contrast to a similar study, where fresh, newly-purchased cane water had bacteriological contents, especially *Escherichia coli*, which is harmful to the body.[13]

The general relationships of drinking or eating with exercise is very strong, that is, from wake-up, preparation, warm-up, actual start of exercise (sub-maximum to maximum intensity), completion, cool-down, muscle relaxation to inter-bout rest and recovery (second set/repetition) ..., followed by the main rest (deep sleep) without psychological burden. This is corroborated by the opinion of the Indonesian national runner Suryo Agung Wibowo, the champion of the 2009 Sea Game Laos, "the biggest temptation after exercising is meal.[14] Changes in work activities (exercise) are also related to: (1) heart pressure during changes in the rate of blood flow, lungs,[15] heart rate and O_2, aerobic to anaerobic when running;[16] (2) the exceeded intensity of exercise (from mild to maximum); (3) increased metabolic waste, lactic acid, CO_2, and H_2O, thereby reducing and measuring an athlete's blood pH levels are of importance.

B. Exercise, Fatigue and Blood pH

The lungs, supported by the chest muscles, is equivalent to the increasing frequency and intensity of contraction–relaxation activities of the muscles of the body. That is, the heart and the amount of blood volume flowing per second or the rate of blood flow lead to an exponential change in the pulse rate from low to higher and then flatten after reaching the maximum volume of O_2 respiration, which exceeds the capacity of the lungs to absorb air (or run out of sugar-burning substances in the blood) while the activity remain to be continued, so it must use the fat energy stored in muscle adipose for subsequent activities. It is this last energy that causes fatigue.[15] During the recovery, an acute fatigue requires O_2, nutrients and water (H_2O) immediately. Thus, fatigue may be related the blood pH of sportsmen. Fatigue can be related to the amount of acid in the body, and the acidity of the body can be controlled by (1) O_2 drainage (O_2 therapy[17] and (2) drinking alkaline pH drinks that can increase the pH level of the body's blood, as suggested by many of the studies above.

MATERIALS AND METHODS

A. Blood and Ultrasonic Piezoelectric Transducer

As noted above, blood contains a very high level of H_2O (80–90%), and an ultrasonic treatment of H_2O with sinusoidal signals by means of a Piezoelectric transducer can cause a cavitation event of decomposition of H_2O into O_2 and H_2. This phenomenon also applies to blood. The present study exposed blood serum to a Piezoelectric transducer at 48 kHz, 10 Vpp, 5 Vdc for 30 minutes. The Piezoelectric transducer was a manufacturer's mechanical wave vibrator made of two thin metal circular plates separated by a dielectric material and there were wires encircling the two plates as negative electrical poles, while the two plates served as the positive poles. The Piezoelectric transducer plates were type 40 with only the flat plate condenser. Since it is of metal, the atoms are not free or bound to one another and the direction of propagation is parallel, linear, and completely uniform. When the metal transducer is dipped in H_2O media whose chemical molecules are free, there will be a non-parallel, non-linear, and not non-uniform motion. The free motion of O_2 and H_2 molecules of H_2O leads to hectic collisions within H_2O molecules in the blood and can cause the breakdown of H_2O molecules into its elements, even though not all H_2O are broken down and the H_2O elements move freely.

B. Blood (free) H_2 and O_2 Elements as a result of Exposure to Ultrasonic Piezoelectric Transducer

The exposure technique was to dip the ultrasonic Piezoelectric transducer directly into the surface of the blood (free-moving blood molecules). As a result, (1) the

H_2 molecules (group 1A) will be very reactive in the blood and look for their partners (group 7A or other groups will make an ionic bonding), for example, $Mg_2SO_4 \rightarrow MgHSO_4$, even expelling partners with negative ions from the alkali group under the hydrogen elements below, for example, lithium (Li), sodium (Na), and potassium (K). (2) The O_2 molecules (group 6A) are more moderate in their ionic reaction with other chemical elements, but O_2 will choose to kill microbes averse to this element. For example, it kills anaerobic microbes but will give life opportunities to aerobic microbes, provided that the microbes are able to use them. During the vibrations, all chemical particles and microbes in fluid continue to vibrate, even difficult to remain static after the source of vibrations is off.

The speed of blood centrifuge can cause the breakdown of blood into two groups: (1) blood plasma samples (low-speed centrifuged) and (2) blood serum samples (high-speed centrifuged). The present study used blood serum, where blood serum is a clear yellowish liquid free of fibrinogen. Blood plasma contains fat (glycerol-3 [$C_{17}H_{33}$]), phosphorus (P), protein (complex compound), glucose ($C_6H_{12}O_6$), ammonia (NH_3), sodium (Na), potassium (K), lactic acid ($C_3H_6O_3$), uric acid ($C_5HN_4O_3$), carbonic acid (CO_2) and others, as nutrients and body waste).

RESULTS

A. Exposure of Blood Serum to Ultrasonic Piezoelectric transducer

In blood serum (centrifuged blood samples).

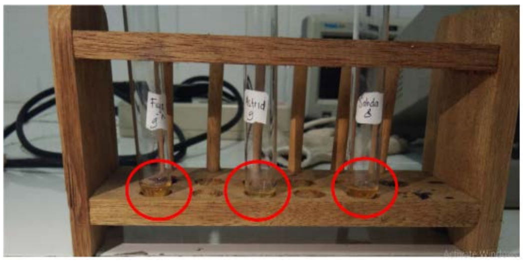


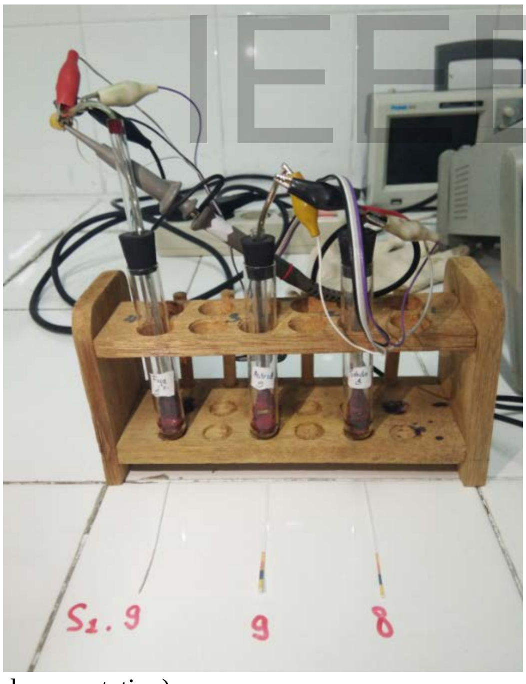
Figure 1. Blood serum prior to exposure to ultrasound Piezoelectric transducer (source: authors' own documentation)

B. Blood serum pH value prior to Direct Blood Exposure to Ultrasonic Piezoelectric Transducer

Figure 2. Prior to the exposure the blood serum pH value of the 3 samples was 9, 9, and 8 or 8.67 on average (source: authors' own documentation)

C. Blood serum during Direct Blood Exposure to Ultrasonic Piezoelectric Transducer

Figure 3. During the exposure to ultrasonic piezoelectric transducer with the function generator the pH value of blood serum samples prior to the exposure was 9, 9, and 8 (source: authors' own



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D. The pH value of blood serum samples subsequent to Direct Exposure to Ultrasonic Piezoelectric Transducer

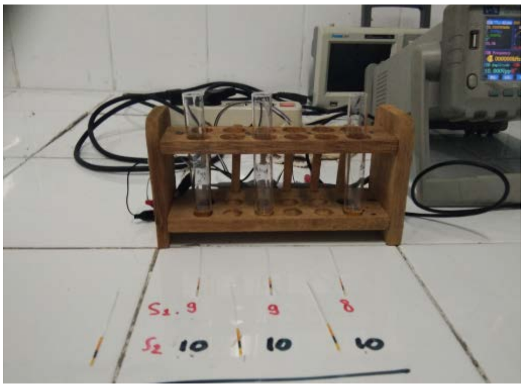

Figure 4. The pH value of blood serum samples after exposure to ultrasonic piezoelectric transducer at 48 kHz, 10 Vpp, and 5 Vdc for 30 minutes was 10, 10, and 10 (source: authors' own documentation).

DISCUSSION

Results of the present study, involving 3 amateur athletes, showed that direct dipping of an ultrasonic Piezoelectric transducer into blood serum samples led to blood cavitation:

$$H_2O_{(serum)} \rightarrow H_{2(serum)} + O_{2(serum)}$$

H_2 and O_2 dissolved in blood serum would react with other elements in the blood serum, leading to a uniform increase in the blood pH (pH of 10), regardless of the initial pH level of the blood serum. As noted previously, H_2 molecules are very reactive to react with blood chemicals, thus increasing the pH level of blood serum. Simultaneously, it reacted in 3 test tubes of the same shape, in the same volume of serum, with exposure to the same type and shape of Piezoelectric transducer. Additionally, the system used was the dipping on the surface of the blood, leading to the same pH level (10) for all samples. Thus, the exposure to ultrasonic Piezoelectric transducer from the same source (48 kHz, 10 Vpp, and 5 Vdc for 30 minutes) results in the same reaction and the constant continuous ultrasonic vibrations react with certain elements, leading different samples to have the same pH. In other word, the blood serum from healthy patients has the same components.

The reactive H_2 molecules would react with blood elements: potassium (as an intracellular element), sodium, calcium. This can increase the pH of blood serum and can react with other elements: fat, protein, minerals in the blood.

Furthermore, the benefits of O_2 derive from its reaction with: (1) sugar:

$$C_8H_{22}O_6 \rightarrow CO_2 + H_2O + \text{energy}$$

(2) iron (Fe), as exemplified by the bonding of ferric sulfate and ferrous sulfate:

$$Fe_2\,(SO_4)_3 + 3\,O_2 \rightarrow FeSO_4$$

in the blood, in which the ferric ions can be toxic in the body.

(3) microbes in the blood, such as: bacteria, fungi, and viruses.

DISCUSSION

1. Blood serum centrifuged from slightly clotted blood samples at a high speed of centrifugation can be serum that removes fibrinogen. In the present study, samples were centrifuged at 3000 to 6000 rpm for 30 minutes, where the speed in some literature and in everyday practice is not clear.
2. The frequency of vibration for ultrasonic exposure was the same (48 kHz), but in terms of intensity (½ amplitude) and the direct current voltage applied remains unclear. Theoretically, it has no effect since it still uses sinusoidal waves.
3. Blood serum containing of (i) glycerol-3 [$C_{17}H_{33}$], (ii) P, (iii) protein complex compounds, (iv) $C_6H_{12}O_6$, (v) NH_3, (vi) Na, (vii) C, (viii) $C_3H_6O_3$, (ix) $C_5H_4N_4O_3$, and (x) CO_2 was subjected to ultrasonic cavitation in a test tube. These elements must be able to react with H_2 and O_2. However, the theory is not yet present, so that it is explained by using general theories:

   a. Hydrogenation (addition of H_2)

   i. Reacting with blood fat:

   Liquid fats $\rightarrow$ solid fats

   Glycerol-3 [$C_{17}H_{33}$] + 3 H_2 $\rightarrow$ glycerol-3 [$C_{17}H_{35}$].

   This reaction produces saturated fats/bad fats) to be stored.[3b]

   ii. Reacting with blood phosphate

   The metabolic products of blood phosphate absorption from the intestine cannot be too acidic than its base so as not to interfere with kidney function. When the blood pH threshold is less than 6.8, the athlete may be comatose or die.[3c]

   iii. Reacting with sugar, if it is in a cell, whereas theoretically the reaction in the blood is not yet present (or does not react).

iv. Reacting with blood ammonia

$NH_{3(g)} + H_2O \rightarrow NH_4OH_{(s)}$

(No reaction with H_2)

v. Reacting with blood sodium or potassium

$2\ Na_2CO_3 + H_2 \rightarrow 2\ NaHCO_3$

b. Oxygenation (addition of O_2)

i. Reacting with blood fat:

According to past knowledge (research[18]), fats outside the body will react with O_2 to become rancid. Would fats in the blood serum oxidized by the ultrasonic cavitation process be damaged?

ii. Reacting with blood phosphate

Phosphate is present in cells (mitochondria) and ATP outside cells (in the bloodstream[19]) has not been much studied (or none). Phosphate is in the form of AMP, ADP and ATP.

iii. Reacting with blood sugar

Oxidized water products and blood sugar reactions can occur

$C_6H_{22}O_6 + O_2 \rightarrow CO_2 + H_2O + \text{heat}$

(humans are able to adapt to O_2 water[20])

4. The duration of blood serum exposure to Piezoelectric transducer was 30 minutes. The basic theory is that ultrasonic Piezoelectric transducer and duration of exposure lead to water breakdown[21] and kill microbes.[2] However, the duration of serum exposure to ultrasonic Piezoelectric transducer which increases the pH of blood samples from amateur athletes (students, same age, had breakfast, no activity/relax) resulted in the same pH (10). The issue for discussion is that is the chemical composition of their blood serum the same?

CONCLUSION

There is a difference between the pH value of blood serum without and with exposure to ultrasonic Piezoelectric transducer. Data analysis showed that the average pH of blood serum without exposure to ultrasonic Piezoelectric transducer was 8.67 and the average pH of blood serum with ultrasonic exposure to ultrasonic Piezoelectric transducer was 10.

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