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Analysis of The Heavy Metal Content of Zinc (Zn) In Tofu Using Atomic Absorption Spectrophotometer (AAS)

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ABSTRACT

Tofu, which is rich in protein, has long been consumed by the people of Indonesia as a side dish. Tofu is a food made from fermented soybeans and extracts from it. One of the metals that is dangerous and should not be eaten is zinc (Zn). Zinc is a type of heavy metal that is soft and easy to purify. This study aims to determine the content of heavy metal zinc (Zn) contained in tofu by using Atomic Absorption Spectrophotometry (AAS). The advantages of an Atomic Absorption Spectrophotometer (AAS) are specific, low detection limit, from the same solution, several different elements can be measured, can be applied to many types of elements in many types of samples, limit levels that can be determined are very area (mg/L to percent). This research uses a descriptive-analytical method to describe or provide an overview of the object under study through the data. And this research uses the wet destruction method, namely the destruction of the sample with the addition of a solution of nitric acid (HNO3) followed by heating and filtering. The results showed that the concentration of heavy metal Zn in tofu was 0.161 ppm, 0.139 ppm, 0.161 ppm, 0.152 ppm, 0.153 ppm, 0.154 ppm, 0.159 ppm, 0.174 ppm, 0.185 ppm, 0.141 ppm, 0.159 ppm and 0.164 ppm. The conclusion is that the levels of tofu Zn contain zinc metal Zn with levels of 10.3325 mg/kg. The levels of zinc metal Zn are still below the threshold level, so tofu is still safe for consumption.

Introduction

Tofu is a type of food that has nutritional value and contains protein with the basic ingredients of soybeans. The need for soybeans reaches 2.3 million tons per year, of which 40% is consumed in the form of tofu, 50% in the form of tempeh and 10% in soybean oil (Buchori et al., 2012). The nutrients contained in tofu are still inferior when compared to animal side dishes, for example, fish, eggs and meat (Widaningrum, 2015). The tofu industry can improve the community's economy, but it can also have a negative impact because the waste produced can pollute the environment (Matilda et al., 2016). Tofu is one of the most popular foods for Indonesians. Tofu is a food that is always present every day, whether it is a side dish for rice or as a snack. Besides being easy to find, the nutritional content is good for our bodies.

The high purchasing power of the people toward tofu food has caused many tofu industries to emerge. The tofu industry is one of the home industries whose production process still uses a simple method. In previous studies, the process of making tofu is mostly done with the first step in selecting the quality of soybeans, among others, by deciding which has large seeds, then washing using clean water and then soaking in a lot of water for 8 hours, the soaking takes a lot of time so that the quantity of tofu production is less. Maximum subsequent work includes the washing process, stripping process, and crushing process so that the soybeans become porridge. Furthermore, providing a thickening agent, compaction process, and cutting (Fitri, 2013).

Many tofu producers do not pay attention to environmental cleanliness it can reduce the quality of the tofu produced, including being contaminated by bacteria and metal chemical compounds. Determined to cause poisoning. Zn is a heavy metal. Heavy metals enter the body tissues of living things in several ways, namely the respiratory tract, digestion and penetration through the skin. Metal absorption through the respiratory tract is quite large, both in aquatic biota that enters through the respiratory system and land biota that enters through dust in the air into the respiratory tract (Darmono, 2001).

Zn is necessary for the body's metabolic activities, but excess amounts can be harmful (Tjay and Rahardja, 2002). After consuming 4 to 8 grams of zinc, symptoms of excessive zinc absorption might include nausea, vomiting, dizziness, heartburn or stomach discomfort, fever, and diarrhoea. Acute poisoning from 2g of Zn might result in vomiting and severe stomach discomfort. In terms of health, Zn may result in an infection of the mucous membranes

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at lethal doses (LD) of 3 to 5g ZnCl2, and 5g of ZnS is deadly. This dosage is extremely risky since chronic oral usage damages the immune system, lowers HDL cholesterol, and causes digestive and cholesterol issues.

Atomic Absorption Spectrophotometer is a tool whose analysis technique is based on the absorption of electromagnetic radiation by unexcited atoms. AAS is used for the analysis of heavy metals such as Zn, Cu, Pb, Fe and others (Dewi; 2009). Previous researchers (Herni, 2011) have analyzed the heavy metal Zn in food samples of mangrove oyster meat. The metal content of Zn, which was analyzed using an Atomic Absorption Spectrophotometer in the Mangrove Oyster sample, was 10.85 mg/kg, which is still normal.

Another study was conducted by Maddusa, et al at the Manado Research and Industrial Standards Institute (BARISTAND) in 2017. Fish samples were taken at three points with two collections, in the morning and afternoon. Point 1 is Cork fish (Channa striata), point 2 is Mujair fish (Oreochromis mossambicus) and point 3 is Cork fish (Channa striata). Each amounted to one fish with a length ranging from 20-25 cm. The sample used for the test is meat that is separated from the bone first.

Processing tofu will produce waste, or there is a residue that can be in the form of waste. Waste if not handled properly, will cause pollution (Indah et al., 2014). Tofu waste is the residue of soybean processing that is wasted because it is not formed into tofu. Tofu waste exists in solid and liquid forms. Solid waste which is the result of cleaning soybeans, the rest of the slurry is usually called tofu dregs, while the result of washing tofu is in the form of liquid waste. Waste that is dominantly wasted is in liquid form and has the potential to pollute waters. The tofu production process will produce liquid waste that comes from soybean cleaning, equipment cleaning, soaking, and printing and if discharged directly into waters, it will smell bad and pollute the environment (Kaswinarni, 2008). According to Rolia & Amran (2015), Untreated tofu waste smells and is black in color. A tofu factory in Bandung is located next to the Citarum River, where the water quality is extremely bad (1,320 L/sec/day, or around 270 tons/day). Industrial waste carrying heavy metal zinc (Zn) enters the Citarum River (Budiman, et al. al., 2012). This raised concerns that the zinc metal would pollute tap water. When it comes to the daily lives of the residents of Tarju Sari Village, water plays a crucial role in the tofu-making process. According to observations, a tofu processing business may be found close to the Citarum River. Industrial garbage enters the Citarum River at a rate of 320 L/sec/day, or around 270 tons/day (Budiman, et al., 2012). This raised concerns that the zinc metal would pollute tap water. When it comes to the daily lives of the residents of Tarju Sari Village, water plays a crucial role in the tofu-making process. According to observations, a tofu processing business may be found close to the Citarum River. Industrial garbage enters the Citarum River at a rate of 320 L/sec/day, or around 270 tons/day (Budiman, et al., 2012). This raised concerns that the zinc metal would pollute tap water. When it comes to the daily lives of the residents of Tarju Sari Village, water plays a crucial role in the tofu-making process.

Method

The descriptive analytical technique of the study was used to ascertain the concentrations of the heavy metal zinc (Zn) in tofu samples. Twelve tofu samples from a single factory near the Citarum River were utilized in this investigation. The research location is Padjadjaran University (UNPAD), where the research was conducted in June 2019. The data collection technique taken during the research in the laboratory was primary data in the form of data on the levels of heavy metal zinc (Zn) in tofu, and heavy metal zinc (Zn) testing was carried out on using an Atomic Absorption Spectrophotometer (AAS).

The tools used in this research are a blender, porcelain cup, funnel, beaker, measuring cup, hot plate, filter paper, Erlenmeyer flask, volumetric flask, analytical balance, oven, goitre pipette, dropper pipette, volume pipette, and atomic absorption spectrophotometry. The materials used are aquabidest, nitric acid (HNO_3 Pa), zinc metal powder (Zn), and tofu.

The research work procedures were (1) prepare tools and materials, (2) mash tofu samples, (3) then weighed as much as 5 grams in porcelain whose weight was known, (4) put them into a 100 ml beaker, (5) added 10 ml of nitric acid (HNO_3), (6) then heated on a hot plate, (7) let stand for a moment, (8) then filter with filter paper in a 25 ml volumetric flask, (9) add distilled water to the mark.

Lambert Beer's Law is used in the computation. By absorbing a certain amount of energy, the electrons of an atom in the atomization system can be temporarily promoted to a higher orbital (light of a certain wavelength). The precise energy (wavelength) required for a certain electron transition in a specific element. Each has a wavelength that is exclusive to a single element. The amount of energy or power used in combustion is known, and the amount that remains may be measured by a detector. By using the Lambert-Beer law to determine how much of this transition occurs, a signal proportionate to the concentration of the element being measured can be obtained. The energy absorbed is directly proportional to the energy required to excite the atom.

Results

Determination of Zn Heavy Metal Content in Tofu

Zn concentration in tofu was determined using an atomic absorption spectrophotometer with a 213.86 nm wavelength. Atomic Absorption Spectrophotometer (AAS) technique's fundamental tenet is that electrons in an atom absorb light energy at a certain wavelength and transition to a higher energy state (excited). By measuring the amount of light energy absorbed, it is possible to ascertain the number or concentration of atoms of the element being tested in the sample since the number of atoms that the light passes through and gets excited about is directly proportionate to the amount of energy absorbed (Estikarini, et al., 2016)

It is then added to a calibration curve with the linear equation y = ax + b, where y is the absorbance value and x is the concentration from the measurement of the standard series. Figure 1 shows how the standard calibration curve is shown.

Table 1. Absorbance Value of Zinc Standard Solution (Zn)

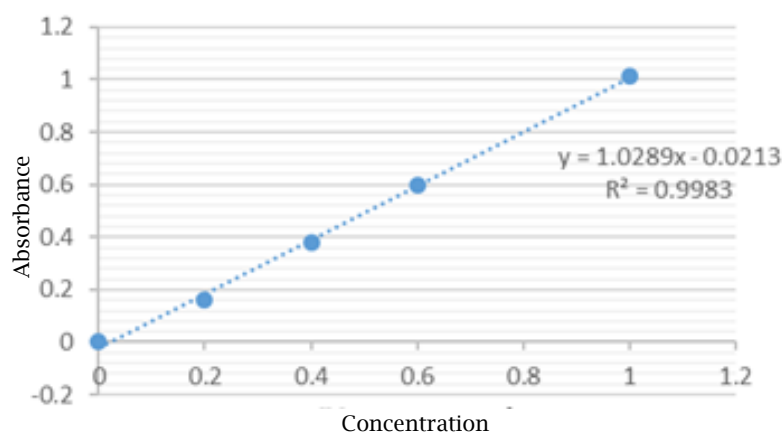| Concentration (ppm)	Absorbance
0.0	0.000
0.2	0.162
0.4	0.382
0.6	0.600
0.8	0.860
1.0	1.013

$y = 1.0289x - 0.0213$
$R^2 = 0.9983$

Figure 1. Standard Curve of Zinc (Zn) solution

The correlation coefficient was achieved in the linearity test for calculating the R2 regression from the standard calibration curve. The correlation coefficient value demonstrates a significant association between absorbance and solution concentration (x-axis) (y-axis). R2 = 0.9983 is the regression coefficient value that was achieved. In order to utilize the curve as a standard curve for evaluating Zn levels in tofu samples along the Citarum River in Banjaran District, Bandung, Indonesia, it is necessary that the R^2 value be close to the ideal.

Table 2. Results of Measurement of Zn Heavy Metal Levels in Tofu

Sample	Zn content (mg.Kg^{-1})
1	10.5890
2	8.2962
3	10.5881
4	9.6930
5	9.7886
6	9.8877
7	10.3896
8	11.9000
9	13.0817
10	8.4878
11	10.3915
12	10.8974
Average	10.3325
Maximum	13.0817
Minimum	8.2962
SD	1.3116

Table 2 shows the levels of heavy metal Zn after measurement using the methodAtomic Absorption Spectrophotometry (AAS). From the results of research conducted on the measurement of heavy metal levels of Zn in tofu samples in the Village around the Citarum River, Banjaran District. With the number of research samples as many as 12 samples, the highest Zn content was obtained in the tofu sample, namely 13.0817 mg/kg, the concentration is obtained from the results of the linear equation y = ax + b.
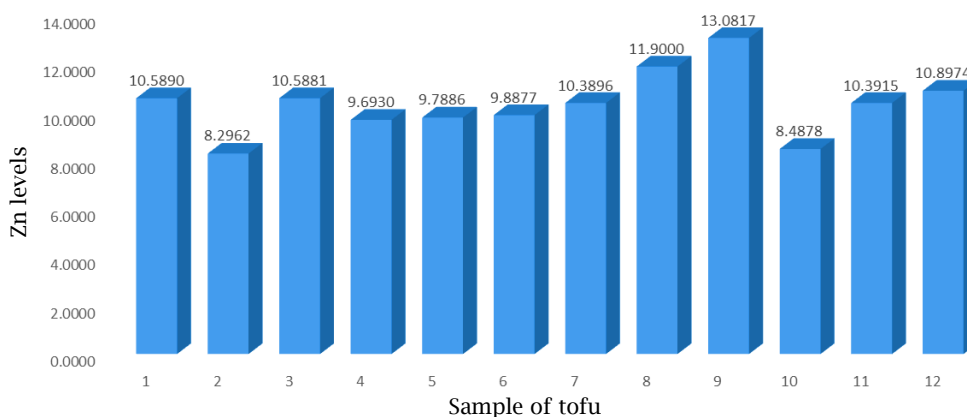
Figure 2. Zn Levels in Tofu

Determination of Detection Limit

The limit of detection (LOD) is the smallest limit test parameter owned by a tool/instrument to measure a certain number of analytes. According to Torowati & Galuh (2014), the detection limit is the concentration or the smallest/lowest amount of analyte in the sample that still shows the absorption value or absorbance on the tool without having to meet the criteria for accuracy and precision. The quantitation limit (LOQ) is the smallest amount of analyte in the sample that can still be measured with accuracy and precision by the instrument/instrument. Determination of the detection limit and quantitation limit can be done in 3 ways, namely: signal to noise, blank determination and calibration curve (Riyanto, 2002).

The LoD test is carried out by measuring the lowest standard concentration that can be detected by absorbance, but it does not need to be quantized as an exact value (Arifin, et al.; 2006). Meanwhile, the quantitation test (LoQ) was carried out by measuring the lowest standard concentration whose absorbance could still be detected and could be quantified with precision and accuracy. The limit of detection is obtained through the regression line equation $Y = 1.0289x - 0.0213$. With the detection limit value obtained, namely 0.0349 ppm means the lowest level that can be detected by Atomic Absorption Spectrophotometry (AAS).

Discussion

The determination of the metal content of Zn in tofu was carried out at a wavelength of 213.86 nm. This wavelength is the wavelength most strongly absorbs energy for the transition of Zn atoms from the ground level to the excitation level. Analysis of a metal element in a sample using Atomic Absorption Spectrophotometry (AAS), the sample used in this study is in the form of a solution and requires destruction to break Zn bonds with organic elements in a sample. In this study, wet digestion was used because in general wet digestion can be used to determine elements with low concentrations. So that these elements do not interfere with each other in the analysis, then one of the elements must be removed. With the destruction process, it is hoped that only the metals are left behind.

In the sample preparation process, filtering is carried out, which aims to separate solids into liquids. The sample was added with 65% concentrated nitric acid (HNO_3) which served as a destructor. This solution is used for organic materials that are difficult to destroy and are heated to complete the destruction.

The technique used in this analysis is the calibration curve method. In this method, a series of standard solutions with various concentrations and absorbances of these solutions are made, which are then measured by Atomic Absorption Spectrophotometry (AAS). The next step is to make a graph between concentration and absorbance which is a straight line through the zero point. By using a linear regression program will get the equation $y = 1.0289x - 0.0213$. From the results of sample analysis obtained absorbance and sample concentration data for heavy metal Zn in table 4.1 shows that the concentration results in all tofu samples are normal, still below the threshold according to SNI No. 01-3142-1998 and SII No. 0270-1990 is 40.0 mg/kg. The low levels of zinc (Zn) are possible because the zinc (Zn) in tofu is low. At a certain concentration, the heavy metal zinc will shift its function and start to harm aquatic life. Of course, this condition has the potential to ruin an aquatic environment (Palar, 2008).

A layer that is easily passed by water, like the layer found in sand or gravel, is referred to as a permeable layer, whereas a layer that is challenging for water to pass through is referred to as an impermeable layer. Water will seep into the soil and combine to form a layer of soil known as an aquifer. When surface water infiltrates into the soil, it dissolves the minerals inside, which causes chemical reactions to occur that alter the water's quality (Dantje, 2015). This shows that the low level of heavy metal zinc (Zn) in the well water used for making tofu is very low, but if consumed continuously in large quantities, zinc (Zn) levels will accumulate in the body, causing various diseases in the human body.

Conclusion

Based on the research that has been carried out, it can be concluded that the average content of heavy metal zinc (Zn) contained in tofu samples in the village in Banjaran District, Bandung Regency, using the Atomic Absorption Spectrophotometry (AAS) method is still suitable for public consumption because of the results of the study. The heavy metal content of zinc (Zn) was 10.3325 mg/kg, still within the normal threshold according to SNI 01-3142-1998 and SII No. 0270-1990 regarding tofu quality requirements of 40.0 mg/kg.

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