Heavy Metal Determination and Health Risks Assessment of Selected Processed Canned Fruit Products

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THESIS DECLARATION

I declare that this thesis entitled "Heavy Metal Determination and Health Risks Assessment of Selected Processed Canned Fruit Products" is the results of my own research except as cited in the references.

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Penentuan Logam Berat dan Penilaian Risiko Kesihatan Produk Buah-buahan dalam Tin Diproses yang Terpilih

ABSTRAK

Buah-buahan dalam tin yang mengandungi banyak khasiat yang hampir setanding dengan khasiat buah segar menjadikannya pilihan kepada pengguna yang mahukan buah-buahan itu sukar untuk rosak. Walaubagaimanapun, buah-buahan dalam tin memberi kesan buruk kepada kesihatan manusia jika dimakan dalam tempoh yang lama dan mungkin telah tercemar dan terkumpul dengan logam berat yang boleh berlaku dalam pertanian, alam sekitar dan aktiviti manusia. Kajian ini bertujuan untuk menganalisis logam berat daripada empat sampel buah-buahan dalam tin terpilih iaitu longan, nanas, laici dan buah-buahan campuran dari pasaraya di Kelantan dengan menggunakan Spektrometer Penyerapan Atom juga menilai risiko kesihatan manusia dalam pengambilan buah-buahan dalam tin di Malaysia. Sasaran Bahaya, Pengambilan Harian Diterima, Pengambilan Mingguan Bahaya dan Indeks Bahaya digunakan untuk menilai risiko kesihatan manusia. Keputusan purata kepekatan logam berat produk buah-buahan dalam tin yang dihasilkan dalam kajian ini ialah Zn > Pb > Cr > Cd > Ni yang disusun mengikut tertib menurun. Bagi risiko kesihatan manusia, purata Sasaran Bahaya ialah 2.69×10^{-4} (Cd), 5.29×10^{-3} (Cr), 9.44×10^{-6} (Ni), 1.54×10^{-5} (Zn) dan 5.52×10^{-3} (Pb). Keputusan Indeks Bahaya ialah 0.01 iaitu kurang daripada 1. Oleh itu, produk buah-buahan dalam tin dalam penyelidikan ini boleh dikategorikan sebagai selamat untuk dimakan untuk manusia.

Kata kunci: Buah-buahan dalam tin, Logam berat, Spektrometer Penyerapan Atom, Penilaian risiko kesihatan, Kepekatan

Heavy Metal Determination and Health Risks Assessments of Selected Processed Canned Fruits Products

ABSTRACT

Canned fruits which contain a lot of nutrients that are almost comparable with the nutrients in fresh fruit make it an option for consumers who want the fruits difficult to spoil. However, the canned fruits had an adverse effect on the health of humans if consumed for long period and may be contaminated and accumulated with heavy metals which can occur in agriculture, the environment also human activities. This study aimed to analyse the heavy metal from four selected samples of canned fruits which are longan, pineapple, lychee, and cocktail from the market at Kelantan by using the Atomic Absorption Spectrometer (AAS) also evaluated the human health risk in the consumption of canned fruits in Malaysia. The Target Hazard Quotient (THQ), Tolerable Daily Intake (TDI), Provisional Tolerated Weekly Intake (PTWI), and Hazard Index (HI) were used to evaluate human health risk. The results of the average heavy metals concentration of canned fruits products generated in this study was Zn > Pb > Cr > Cd > Ni which arranged in descending order. For the human health risk, the average of (THQ) was 2.69×10^{-4} (Cd), 5.29×10^{-3} (Cr), 9.44×10^{-6} (Ni), 1.54×10^{-5} (Zn) and 5.52×10^{-3} (Pb). The (HI) result was 0.01 which is less than 1. Therefore, the canned fruits products in this research can be categorised as safe to consume for humans.

Keywords: Canned fruit, Heavy metal, Atomic Absorption Spectrometer, Health risk assessment, Concentrations

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LIST OF SYMBOLS

$>$	More than
$<$	Less than
℃	Degree Celsius
℉	Fahrenheit
µ	Micro
±	Standard error
%	Percentage

LIST OF ABBREVIATIONS

FAO	Food and Agriculture Organization
WHO	World Health Organization
MFA	Malaysian Food Act
AAS	Atomic Absorption Spectrometer
Cd	Cadmium
Cr	Chromium
Ni	Nickel
Zn	Zinc
Pb	Lead
Cu	Cooper
µg	Microgram
Mg	Milligram
Mg/kg	Milligram per kilogram
MRL	Maximum Residue Limit
Mm	Millimeter
L	Liter
mL	Milliliter
µg/L	Microgram per liter
mg/L	Milligram per liter
H_20_2	Hydrogen peroxide
HNO_3	Nitric acid
HCL	Hydrochloric acid
$Pb(NO_3)_2$	Lead nitrate

$(Cr(NO_3)_3.9H_2O$	Chromium nitrate
$Zn(NO_3)_2$	Zinc nitrate
$Cd(NO_3)_2$	Cadmium nitrate
$Ni(NO_3)_2$	Nickel nitrate
Mg/kg/day	Milligram per kilogram per day
Mg/kg/week	Milligram per kilogram per week
TDI	Tolerable Daily Intake
EDI	Estimated Daily Intake
EWI	Estimated Weekly Intake
PTWI	Provisional Tolerable Weekly Intake
THQ	Target Hazard Quotient
HI	Hazard Index

CHAPTER 1

INTRODUCTION

1.1 Research Background

Fruits and vegetables are the sources of nature that contain various types of important vitamins, minerals, carbohydrates, protein, fiber also has electrolytes, phytochemicals, and antioxidants (Pem & Jeewon, 2015). The proper diet that follows guidelines from the Ministry of Health Malaysia (MOH) for the latest food pyramid 2020, has been suggested that the fruits must be at the bottom of the food pyramid compared to 2010 that the fruits and vegetables in stage 2. Therefore, fruits and vegetables are important as a human diet without having a limited age. A lot of research has proven the benefits of fruits such as pineapple (*Ananas comosus*) can heal in disease of bowel movement and gastrointestinal function also reducing the risk of diabetes and cerebrovascular disease (Mohd Ali, Hashim et al., 2020). Longan (*Dimocarpus longan*) shows the ability in improves memory and vision health (Hesam Shahrajabian, Sun & Cheng, 2019) and for lychee (*Litchi chinensis Sonn*), Hesam Shahrajabaian, Sun & Cheng (2021) stated that Oligonol in lychee is an anti-influenza virus action.

Public awareness about the health benefits when eating fruits and vegetables is increasing well every year. It has been proven when the concern of healthy food arises since 2000 and the consumers more educated in maintaining good health since the changes in lifestyle (Mamun, Hayat & Zainol, 2020). Therefore, the fruits are more versatile now which not just sell in fresh conditions but also sell in processing fruits such as in canned and pickled. The well-known fruits that have a process to sell as canned products are pineapple, longan, lychee, rambutan (*Nephelium lappaceum*), and cocktail. The cocktail is the canned fruits that have mixed many types of fruits in one can such as mango, peach, pineapple, and other mixed fruits.

Canning is the method to preserve the food to ensure the food can be available in a long-lasting time and it needs to undergo the process and seal (Abdullahi et al., 2016). As an example, in the lychee canned fruits process, it will select the great and mature lychee to use as a canned fruits product. After washing the fruits, lychee will be dipped in a solution of 0.1% potassium permanganate. Then, it will be rinsed with water for about 5 minutes and continues with peeling and pitting using a lychee peeler. The pitting lychee will be added with 30^{o} Brix of hot syrup and filled into the cans and precleaned it is using boiling or steam water. The cans must be sealed first in 5 minutes blanching at 70 to 80 ^{o}C, the function is for removing the remaining gases. The last step is retorting at 116 ^{o}C to 121 ^{o}C for 15-20 minutes (Chen, 2019). Canned fruits have already become the choice for the people that love to eat the fruits in many ways. It is easy to eat, just open the cans and eat without the need to peel the fruits.

Next, the usage of cans as the food packaging needs to have monitored strict procedures, especially during the manufacturing process. The heavy metal contamination, inadequate storage, pasteurization, chemical treatment, and the surrounding indoor environment during the canning process could be the factors of the contamination in canned fruits (Shokr et al., 2016). Izah et al., (2016) stated that the heavy metal that could contaminate the canned fruits are cadmium, zinc, copper, and chromium which can be toxic and give harmful effects on human health when consumed.

Finally, canned fruits must adhere to the World Health Organization's (WHO) and Food and Agriculture Organization's (FAO) permitted level guidelines (FAO). In this study, the determination of heavy metals in canned fruits will be analysed to ensure the consumption of canned fruits is safe for humans. Heavy metals such as cadmium (Cd), lead (Pb), and chromium (Cr) should be held below 0.2, 0.3, and 0.1 mg/g, according to WHO (2011). In ensure the canned fruits products was safe in human consumption intake, The Provisional Tolerable Weekly Intake (PTWI) for adults must not exceed 7.0 mg/kg/week (Cd), 23.3 mg/kg/week (Cr), and 35.0 mg/kg/week (Pb) as set by WHO/FAO (2011). The Hazard Index (HI) must be less than 1 which means safe consumption.

1.2 Problem Statement

First, IBIS World (2020) has reported the industry of processing fruits have shown ascending pattern in five years ago and as predicted will increase each year because of high demand especially among urban people. The people are more focused on healthy lifestyles. Canned fruits are a favorable product to the consumer because already satisfy the dietary need (Felix, et al.,2016). However, even the demand in industry processing such as canned fruits rise, the nutrition values in canned fruits must have a difference if compared with fresh fruits especially in heavy metal elements because it will depend on the process and handling method after the harvesting process.

Next, water, soil, and food are the components that can bring the pollution of heavy metals to enter the body. The concern about the heavy metal's absorption into the fruits also rises because the fruits can be contaminated from the soil and canned fruits, it can contaminate too with the cans. The uncontrolled intake of heavy metals can cause health problems such as kidney disease, cancer, and other chronic disease (Engwa, et al., 2019). The material to produce cans which is solder can create contaminate and heavy metals in canned products. The migration of heavy metal toxicity from metallic pack-aging material can be the reason for contamination of heavy metal easily happen.

Lastly, the awareness towards heavy metals in canned fruits needs to be nurtured so, that people will be more careful in the food content of each food taken. The growing process in the food sector especially canned fruits makes the people did not aware of the foods that have been chosen to eat. Just from the diet, the heavy metal easily exposes into a human when it has already been in the foodstuffs (Sultana, et al.,2017). Therefore, people must know the importance of awareness of heavy metal intake from canned fruits.

1.3 Significance of Study

The fruits can be exposed to heavy metals in the tree because the heavy metal in the soil can contaminate the fruits. Heavy metals are not degradable, when the body cannot metabolise and synthesised the heavy metals, they will be toxic to the body (Singh, et al.,2018). However, when fruits are processed to be sold as canned fruits, the level of contamination may be higher. Several samples of canned fruits were used to analyze the level of heavy metal contamination. This research had gained knowledge to the people about the heavy metals that found commonly such as arsenic, copper, lead, and cadmium was affected the health and environment. The allowed amount of heavy metal in canned food products was set by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO), so a comparison with canned fruits was essential. The comparison was important to make because if the amount of heavy metal exceeded the permitted level, the food is a danger to consume. It was helped the consumer to more aware of either safe or not to the human body. The consumption of fruits especially in canned fruits can be a pathway of heavy metals to expose to humans (Ugulu, Unver & Dogan, 2016).

The heavy metal determination of canned fruits was analysed using Atomic Absorption Spectrometer (AAS) and the wet digestion method was used as a sample preparation technique. The AAS results were compared to WHO and FAO's maximum allowed volume of heavy metal. When using the proper procedure, the reliable result for heavy metal residues in canned fruits was achieved. The Tolerable Dairy Intake (TDI) and Provisional Tolerable Weekly Intake (PTWI) set by WHO/FAO were used as the guidelines in the health risk assessments. The TDI and PTWI were referred to the WHO/FAO (2011) to know the maximum limit allowed for the human intake of canned fruits products. It will help the humans ensure the foods were safe when the Hazard Index (HI) is less than 1.

1.4 Objectives of Study

The objectives of this study were to

1. Extract the heavy metal from four selected samples of canned fruits, (longan (*Dimocarpus longan)*, pineapple (*Ananas comosus)*, lychee (*Litchi chinensis Sonn*) and cocktail).

2. Determine the heavy metal concentration in canned fruits using Atomic Absorption Spectrometer (AAS).
3. Evaluate human health risk in the consumption of canned fruits in Malaysia.

1.5 Scope of Study

Heavy metal contamination such as lead (Pb), zinc (Zn), Cadmium (Cd), nickel (Ni), and chromium (Cr) in selected canned fruits purchased from the local market was the focus of the study. In this study, four samples of canned fruits which were longan, pineapple, lychee, and cocktail were used to extract and determine the heavy metals contamination. Atomic Absorption Spectrometer (AAS) was used to analyze the heavy metals concentration in canned fruits.

Moreover, the results of the AAS study were compared to the World Health Organization's and the Food and Agriculture Organization's (FAO) allowed heavy metal levels to see if the heavy metals in canned fruits the safe level were below. This research study was also determined the human health risks associated with canned fruit intake. The Tolerable Daily Intake (TDI), Provisional Tolerable Weekly Intake (PTWI), Total Hazard Quotient (THQ) and Hazard Index (HI) were becoming the guidelines in the health risk assessments. The TDI and PTWI in canned fruits products were set by WHO/FAO (2011), the results from the health risk assessments were compared with the TDI and PTWI.

CHAPTER 2

LITERATURE REVIEW

2.1 Heavy Metal

Heavy metals can be found in a variety of places, including soils, water, the atmosphere, manufacturing, and food, and some of them have essential metabolic activities in living organisms. Heavy metals naturally are the crust of Earth and cannot be degraded and destroyed so, that is the reason heavy metals can exist in an environment. Essential heavy metals, such as iron (Fe), copper (Cu), zinc (Zn), cobalt (Co), manganese (Mn), and molybdenum (Mo), may have benefits and are essential in human biochemical processes, whereas toxic heavy metals, such as mercury (Hg), cadmium (Cd), lead (Pb), tin (Sn), and chromium (Cr), have no role in biochemical processes and only have a negative impact (Massadeh & Al-Massaedh, 2017). Some of the heavy metal exists as sulfides such as arsenic, nickel, gold, and lead while manganese, selenium gold, and aluminum as oxides. Several heavy metals can exist in both sulfides and oxides which are copper, iron, and cobalt (Azeh Engwa, et al., 2019).

Usually, heavy metals are toxic even at low concentrations and able to enter the human body from the food intake and store up and create damage in the body

(Ayangbenro & Babalola, 2017). If too many toxic heavy metals, it will affect the environment because the high toxic in water and soil can be contaminated. Mishra, et al., (2018) stated the heavy metals can transfer into the food chain when they are already absorbed into underground water and soil, pollution of water and soil will happen. It can alter the proper function in humans or living organisms if they eat it in high concentration. However, heavy metals still have advantages because it still plays important role in keeping the ecosystem functioning. As an example, the combination of iron (Fe) and oxygen (O_2) can give benefits to industrial and biological sectors (Nkwunonwo, Odika & Onyia, 2020).

2.1.1 Classification of Heavy Metals

Heavy metals are divided into two which are essential and non-essential (toxic) which give either direct or indirect to human health. Essential heavy metals have a function in biochemical activities and diverse physiological in the body. Copper, cobalt, iron, nickel, magnesium, molybdenum, and zinc are examples of essential heavy metals. Oyagbemi, et al., (2020) stated zinc is good in minimizing infection, prevention lung injury, and increasing the immune response which benefits against COVID-19.

Non-essential heavy metals did not have a role in the biochemical process and have the potential to become toxic either in the environment or humans. When heavy metal enters the human body, it can bioaccumulate causing adverse effects after the process (Azeh Engwa, et al., 2019). An example of non-essential heavy metals is mercury, cadmium, lead, tin, chromium, and arsenic. Exposure to lead can disturb body function such as in cardiovascular and neurological (Manna, Debnath & Singh, 2019).

2.2 The Heavy Metal in Fruits

Fruits are already known as healthy foods. The doctors and nutritionists will recommend fruits as an important intake in the human diet other than vegetable intake. Fruits can be defined as the plant source which has fleshy parts around seeds, sweet taste, can be eaten as snack or dessert also can eat in raw. The consumption of the fruits at least two servings as recommended by the nutritional and global recommendation because its vitamin, dietary bioactive, mineral, and other contained in the fruits will give health benefits in the body (Wallace & et al., 2019). However, the fruits tend to take up the heavy metal from the soil, and when the heavy metal contaminants into the fruits, it will give an impact on health because it will transfer a long food chain.

The growth media such as water, soil, and nutrients solution can be the source of heavy metals in fruits where it will transport, translate, and accumulate in transportation mechanism. Lead and cadmium are examples of unnecessary heavy metals because only become toxic in the body. Cadmium can lead to renal damages and can stay for a long time in the body while lead can produce inflammation cascades in the tissue of the human body (Boskabady, et al., 2018). The heavy metal in fruits is unavoidable, it still can be used but is needed in permitted guidelines set by WHO and FAO. The important aspect in quality assurance is heavy metal contamination in food so, the analysis is needed to ensure the heavy metal contamination in fruits did not exceed the international permitted limit (Amala Ezeilo, et al., 2020).

Another reason heavy metal pollution increasing in fruits is because of the impact of fertilizer and pesticides which have heavy metal elements. Some plants can store the heavy metals in tissue cells and can grow even in contaminated soil (Sandeep, Vijayalatha, & Anitha, 2019). Hussein Ibraheen, & Ali Abed (2017) reported the accumulation of zinc, lead, and chrome elements in the fruit of Quercus rotundifolia and growing in soils polluted with up to 20 times higher than the same growth plant is contaminated with these elements. Fertilizers are important in increasing the nutrient in the soil to make the fruits grow healthily but the application of that is known as a source of heavy metal especially in chemical fertilizer. The fertilizer from chemicals will produce the plant with the toxic effect which accumulates in the human body and its dangerous. Heavy metals such as arsenic, cadmium, and uranium may accumulate in the soil after repeated applications of chemical fertilizer. Fertilizers such as triple superphosphate, for example, contain trace elements such as cadmium and arsenic, which accumulate in plants and then enter humans via food chains, posing health risks (Chandini, et al., 2019).

The temperature, moisture, organic matter, pH, and nutrient supply all influence heavy metal absorption and deposition in plant tissues. Metals from the parent rock often have a context level of soil, metals may be transformed to mobile forms under certain conditions (Tomáš, Árvay, & Tóth, 2021). The accumulation of heavy metals is also influenced by plant species. However, the plant uptake or soil-to-plant move influences of metals determine the efficacy of plants in extracting heavy metals (Onakpa, Njan & Kalu, 2018). Therefore, the fruits are easily contaminated with heavy metals even at low percentages because the factors to get heavy metals is starting from the soil when planting the fruits.

2.3 Heavy Metal in Canned Fruits Products

Canned fruit products have become the choice of buyers therefore, it’s easier to find in the market with various brands and fruits to choose from it. Carbohydrates, fats, vitamins, nutrients, and trace elements are available in canned fruits and act as important sources in the product. Massadeh & Al-Massaedh (2017) reported during 2016, the interest in estimation of contamination levels of toxic heavy metals is increasing because of the wide consumption of the products by the people which rise in the heavy metal intake.

The production of canned fruits starting from the planting fruits until the manufacturing process of products has the potential to be exposed to heavy metals. Frequent wastewater irrigation has a direct impact on the physical and chemical characteristics of soil so, heavy metal contamination could occur if wastewater is used for crop cultivation regularly (Khan, et al., 2017). Heavy metal contamination of soil, such as copper, zinc, lead, mercury, chromium, copper, and nickel, occurs when used in a long-term practice of wastewater for agricultural purposes. It will influence the fruits to contain heavy metals too when using that type of soil.

Canning is the term used to describe the practice of storing food in a package and exposing it to a thermal process to extend its shelf life. The pathogenic bacteria can be destroyed, spoilage organisms can be killed or controlled, and have a low impact on food and physical qualities. The majority of food cans are manufactured and filled each year around the world, with just a limited few containing plain internal tin-coated steel bodies. Tinplate is the steel sheet, coated on both sides of pure tin that has been used in the production of cans (Abdalrahman, 2017). However, the contact between food and metal packaging can be a source of trace element leakage, which can be toxic to humans if consumed. Zheng, Tian, & Bayen (2021) reported the concentration of heavy metals, such as aluminium, and tin, found in canned fruits maintained at room temperature for a prolonged period exceeds the FAO/WHO Codex Alimentarius Commission's approved limits.

Next, any trace elements are extremely dangerous, and many experiments are focused on assessing their quantities in canned food. Table 2.1 shows the summary of the previous studies on the concentration of heavy metal residues in processed canned fruits products and Table 2.2 is the permitted heavy metal guidelines. The research conducted in Metro, Manila was observed the heavy metal that was lead, chromium, and cadmium in ten random canned fruits products which five brand canned fruits of peach, three lychees, and two pineapples. The result showed chromium and cadmium presented in all of the products but safe to consume. In four peach samples, the lead level was above the permitted secure limit, while the remaining syrup samples were below the instrument's detection level (Wilson, 2021). Tin contamination in pineapple and cocktail canned fruits was found to be greater than the WHO's permissible level in research (Deshwal & Panjagari (2020). According to Abdalrahman (2017), the result from canned pear, peach, and pineapple have exceeded the limit permissible level. Meanwhile, the result from Divis, et al., (2017) showed the concentration of chromium, cadmium, and lead in canned fruits of apricot, strawberry, and mango were under the maximum level of 0.05 mg. kg^{-1} set by EU.

Table 2.1: Summary of previous studies on the concentration of heavy metal residues in processed canned fruit products

Processed canned fruits products	**The concentration of heavy metals**						**Locations**	**References**
	Cd	**Cu**	**Pb**	**Fe**	**Zn**	**Cr**		
Tomato canned fruits	-	7.88 ± 6.81	1.17 ± 1.08	-	3.98 ± 4.03	-	Khartoum state, Sudan	Abdalrahman, (2017)
Cherry canned fruits	11.88 ± 0.15	-	-	186.5 ± 4	-	12.12 ± 0.19	Rwanda, Africa	Asema & Parveen, (2018)

Peach canned fruits	-	1.425 ± 0.33	9.577 ± 0.53	65.80 ± 4	-	15.07 ± 0.11	Brazil	Leao et al., (2016)
Strawberry canned fruits	0.76 ± 0.01	0.997 ± 0.01	-	8.443 ± 0.30	-	195.4 ± 8.56	Haripur, Pakistan	Abbasi et al., (2020)
Pineapple canned fruits	0.75 ± 0.63	0.24 ± 0.15	0.98 ± 0.00	1.23 ± 0.02	2.21 ± 0.00	-	Rwanda, Africa	Mukantwali et al., (2017)
Fruit cocktail canned fruits	1.770 ± 0.08	0.073 ± 0.01	1.74 ± 0.208	14.31 ± 1.30	-	10.46 ± 0.228	Mansehra, Pakistan	Abbasi et al., (2020)
Longan canned fruits	-	17.34 ± 0.4	22.65 ± 0.23	-	6.54 ± 0.03	-	Malaysia	Ang, (2019)

Table 2.2: Maximum Residue Limits (MRL) of heavy metals concentration (mg/kg) in processed canned fruits products that are reported by WHO/FAO (2011) and Malaysia Food Act 1983 & Regulations 1985.

Types of Heavy Metals	WHO/FAO	MFA
Cadmium (Cd)	0.05	1.0
Nickel (Ni)	0.3	-
Lead (Pb)	1.50	2.0
Copper (Cu)	10.00	30.0
Zinc (Zn)	30.00	-
Chromium (Cr)	0.03	-

The maximum residue limits of heavy metals concentration are important as a guideline to ensure the heavy metal is under the concentration that is allowed. World Health Organization (WHO), Food and Agriculture Organization (FAO), and Malaysia Food Act (MFA) are the organization that has set the permissible limits of concentration heavy metal for the food. The data that will obtain from the study will be compared with WHO/FAO and MFA to analyse the concentration of heavy metal in canned fruits either permitted or otherwise.

2.4 Toxicity of Heavy Metal

Heavy metal is widely used in various types of industries such as the paints industry, herbicides, pesticides, and cosmetics. During combustion of industries purpose, some of the elements are absorbed into the air, while others are discharged into the soil or water sources as effluents. The use of chemicals, insecticides, fertilizers, and other heavy metals in agriculture has been a secondary cause of heavy metal contamination (Briffa, Sinagra, & Blundell, 2020). The long-term effects of heavy metal toxicity in the human body can cause mutation and cancer (Engwa, et al., 2019). In the food chain, by bioaccumulation and bioaugmentation, the metals give a negative impact on ecosystem life, including humans, plants, and animals (Ali, Khan, & Ilahi, 2019).

2.4.1 Lead (Pb)

Lead is a bluish-grey metal that is found in trace quantities in the earth's crust. This metal appears in the solid state under standard environmental conditions, it is compact, highly malleable, ductile, and very light, with low electrical conductivity as compared to most other metals but when exposed to air, it will tarnish to a dark grey. Pb is the chemical symbol for the lead which acronym for plumbum in Latin word, meaning soft metal. Lead is one of the most dangerous toxins in the environment, and it can contaminate the air, water, and agricultural soil. Then, it can be a major environmental problem because of its negative effects on human health and the environment. Although lead is naturally present in the environment, human processes such as fossil fuel burning, and manufacturing contribute to the release of high quantities of metal (Borah, Kumar & Devi, 2020).

Lead functions in the various industrial, domestic and agricultural uses. Lead is also used in the manufacture of lead-based paints, cosmetics, petrol, solder, and tubing, resulting in elevated levels of lead contamination in humans. The accumulation of industrial waste from the battery, plants, and soils, as well as an increase in vehicle consumption contributing to higher levels of pollution, has resulted in the development of lead. Jain, & Gauba (2017) stated that people are easily exposed to lead contamination through drinking water because the water will pass through the pipe made from lead. The major causes of lead pollution that influence human health include the generation of reactive oxygen species as a consequence of inhaling lead particles, either directly by occupational workers or unintentionally by other humans. It is resulting in oxidative damage and health-related unfavorable effects. (Rehman, et al., 2017).

Besides, fruits and vegetables polluted with high levels of lead from the soils where they were grown will cause lead toxicity. Lead is easily found in the soil because of the soil properties and agricultural activities such as sludge application on agricultural fields. Ali & Nas, 2018 stated an excessive of lead in soil can cause harm to the root system and a reduction in the strength of transpiration. Plants have been shown to generate reactive oxygen species (ROS) and increase antioxidant enzyme activity when exposed to lead (Malar, et al., 2016). In plant cells, ROS formed as a result of oxidative stress causes a variety of negative effects, including photosynthetic inhibition, ATP inhibition, and DNA damage (Pizzino, 2017).

Some previous studies have shown the lead can give an effect on human health. Vermeir, et al., (2021) reported that the blood lead levels have been linked to lower IQ levels, delaying neurobehavioral growth and interrupting distinct cognitive development in three-year-old children. In adults, lead can cause long-term effects such as kidney damage and the risk of high blood pressure. Exposure to lead can be risky to pregnant women which can cause miscarriage, stillbirth, prematurity, and birthweight low during pregnancy (WHO, 2019).

2.4.2 Cadmium (Cd)

Cadmium is known as a smooth, ductile, silvery-white metal with a bluish texture, lustrous, and electropositive metal particle. Cadmium has no odour or flavour and is extremely toxic. It has eight isotopes and can produce a wide range of organic amines, sulfur complexes, chloro complexes, and chelates (Rafati Rahimzadeh, et al., 2017). The melting point for cadmium is 321 ^{o}C, the boiling point is 765 ^{o}C, and the atomic number is 48. As a result of human activities, cadmium has been present in the environment. The use of cadmium as a corrosive reagent in industry, as well as its use as a stabiliser in PVC materials, paint pigments, and Ni-Cd batteries, are all constant sources of cadmium toxicity (Genchi, et al., 2020). The factors that contributed to the rise of cadmium level in climate change are volcanic activity, the steady degradation and abrasion of rocks and soil, and forest fires.

Cadmium is a pollutant developed by the industries of fuel combustion, metallurgy, metal plating, cement, ceramic manufacture, pigments, and batteries. Mostly, cadmium is used as an anticorrosive for steel electroplating and in plastics, cadmium sulphide and selenide are widely used as pigments (Mohankumar, Hariharan, & Rao, 2016). Zhai, et al., (2015) stated there are methods either physical or chemical to remove the cadmium in industrial from release into the environment but it is pricy and does not effective, so it does not have any approval for the treatment of cadmium toxicity. The colorimetric approach has been extensively and consistently utilised for the detection of numerous heavy metal targets because of its low cost, mobility, and ease of operation (Zhang, et al., 2021).

In the 2004 FAO/WHO workshop, the organisations decided the fruits and vegetable consumption must be at least 400g per day to prevent chronic disease especially in less developed countries (WHO, 2015). However, a heavy metal which usually available in the soil can make the fruits and vegetables toxic. Root vegetables are highly susceptible to cadmium accumulation in plants and have a high bioaccumulation index (10 and above) and their content in plants is also directly proportional to its content in the earth. The cadmium is readily absorbed by the root system and leaves, and that its absorption is proportional to its concentration in the atmosphere, independent of soil properties (Zwolak, et al., 2019).

In addition, the biological process did not involve cadmium and it will only disturb the activities of enzymes and drag down the crop productivity (Chellaiah, 2018). Through the food chain, cadmium can enter the human body. Al-Lami, Khudhaier, & Aswad, (2020) stated when a person is exposed to cadmium from their food, drinking water, or breathing air, it accumulates in their bodies and has a variety of negative effects on their health, mostly affecting the kidneys, liver, and vascular system. In low doses of cadmium, it can cause cough, headaches, nausea, and vomiting while if continuous exposure to contaminates cadmium in drinking water can cause chronic anaemia (Burke, et al., 2016).

2.4.3 Chromium (Cr)

Chromium can be found in Earth Crust in various oxidation states from -2 to +6 in nature. It is known as a crystalline metal with an atomic number of 24 and a density of 7.14 g/m that is translucent and steel-grey in appearance. Chromium concentrations in soil range from 1 to 3000 mg/kg, in seawater from 5 to 800 g/L, and in rivers and lakes from 26 g/L to 5.2 mg/L (Aslam, & Yousafzai, 2017). Chromium (III) and chromium (IV) are the most stable state, and both have emerged from industries. Since the 1960s, steel mills have mostly utilised chromium (0) in its metallic state as a component of iron-based alloys such as stainless steel and tin-free steel, which are less costly than tin steel. (Vimercati, et al., 2017).

Chromium has benefits for medical purposes when it is in a low concentration such as for apparatus medical and implant dental because it can create a corrosion-resistant oxide layer on the alloy's surface. In the human body, chromium is involved in the metabolism of protein and human lipid but in low concentration which is usually around 100 µg in daily food intake (Achmad, Budiawan, & Auerkari, 2017). Chromium (III) acts as a nutritional supplement but chromium (VI) is toxic until can disturb the cells become damage to DNA and alter the gene code (Sun, Brocato, & Costa, 2015). The industries workers which expose to chromium (VI) can be suffered health problems when inhaling the aerosols. Ray (2016) stated the exposure effect from chromium (VI) can lead the irritation and damage to the eye, asthma, kidney damage respiratory cancer also teeth degradation, and discoloration.

Besides the industrial sector, the agriculture sector is also the sector which easily exposed to heavy metal toxicity. Heavy metals are abundant in soil and groundwater because of the effect on extensive usage in industrial and production operations such as leather manufacturing and tanning. Aji, Masykuri, & Rosariastuti, (2017) stated chromium pollution affects the structure, operation, and ecological processes sectors, such as metal uptake by food crops in the food chain, and therefore human and animal health. Chromium is taken up by plants through important ion carriers such as sulphate and the speciation of chromium effects depend on its uptake, concentration, and translocation (Ertani, et al., 2017).

2.4.4 Nickel (Ni)

Nickel, a well-known heavy metal, is present in the atmosphere in very low quantities. Nickel is a solid silver-white hard transition material that can be found in both soil forms and meteorites, as well as erupting from volcanic eruptions. Commonly, nickel has been used in stainless steel, coin, and dental treatment in different forms. Nickel metal, nickel compounds, and nickel-containing alloys are used widely in transportation goods, electronics, food and beverage processing, and many other applications (Buxton, 2019). This shows the future of exposure to nickel metal, nickel compounds, and nickel-containing alloys is extensive.

Next, nickel alloys and nickel derivatives are used in a wide range of consumer and industrial applications. Genchi, et al., (2020) stated the unique physical and chemical properties of nickel make it important in industrial metallurgies in a wide range of metallurgical processes, including alloy manufacture. Nickel (II) compounds can be used as an enzyme activator and contributor to metabolism reactions at low levels but when the usage of nickel too much, it can lead to pollution (Kumar, et al., 2019). The permissible limit of nickel metal ions in human consumable water is 0.02 mg/L, if nickel (II) ion concentrations above this limit can cause a variety of diseases such as skin dermatitis and anaemia (Zhang, & Wang, 2015).

Nickel can occur metal allergy. It can cause allergy when nickel-containing products come into close and sustained contact with the skin, sweat causes nickel to corrode, releasing nickel ions that are absorbed by the skin and causing an allergic reaction. According to Saito, et al., (2016), the percentage of females' allergy with nickel is 13–18 % while males only 3-6 %. Nickel ions are active allergens and can cause skin irritation when released from different alloys.

2.4.5 Arsenic (As)

Arsenic (As) is a metalloid material that is abundant in the natural world and occur through the cycles of water, soil, air, and living system. The metalloid is the property between both metallic and nonmetallic. It's also present in lower concentrations in the air and food, especially crustaceans and seafood. Arsenic characteristic is an odourless, almost tasteless poison. It is found in three different valence states which are arsenic (o), arsenic (III), arsenic (V), and arsine gas, also has three different forms which are inorganic salt, organic salt, and gaseous form (Kuivenhoven, & Mason, 2019). Arsenic can release into the environment through the process of mining and natural phenomena such as volcanic eruption.

Arsenic is also used in the industry sector. Previously, arsenic has long been employed as a wood preservative and also been utilised as defoliants in the distillation of wine, whiskey, beer, and other alcoholic drinks (Lopes, Stokes & dos Santos Bobadilha, 2019). Carlin, et al., (2016) stated arsenic is used as a by-product in the process of smelting the ore with cobalt. zinc, lead, and nickel. Arsine gas is used in the manufacture of gallium arsenide which is used as components in microwave devices, semiconductors, and light-emitting diodes (Kuivenhoven, & Mason, 2019). However, the environment can be polluted if many industries use arsenic because arsenic is also known as heavy metal toxicity.

Next, arsenic did not result in a good effect if exposed to a human. Exposure to arsenic by humans can occur through groundwater, food, and atmospheric air. Arsenic has been linked to some complications in body organ systems, including the integumentary, neurological, and reproductive. Hong, Song, & Chung, (2014) reported that arsenic was confirmed as a carcinogenic agent in humans infected with skin and lung cancers. Even the factor of exposure arsenic because of environment and food, there is proof the toxicity of arsenic has the difference between men and women. According to some research, arsenic-related skin disorders impact men rather than women (Ferrario, Gribaldo, & Hartung, 2016).

The agricultural sector is important to ensure that food such as vegetables or fruits can be supplied to humans. Therefore, the safety of food must be emphasized to avoid any health effects, but the toxicity of heavy metals cannot be avoided because always present in the soil. Arsenic is non-essential metal for the plant, especially in high concentrations. Arsenic toxicity in the plant will affect the morphological, physiological, and biochemical of the plant. Arsenic toxicity disturbs the metabolic activities of cells by directly reacting with enzymes and proteins; as a result, photosynthesis, respiration, transpiration, and plant metabolism cycles are severely disrupted (Hasanuzzaman, et al., 2015).

2.4.6 Zinc (Zn)

Zinc is the fourth metal after iron, aluminium, and copper. It is the 23 most abundant metal element in Earth's crust and it can rise because of the usage of waste in human activities. Zinc looks lustrous bluish-white metal, fragile and crystalline at normal temperature. If zinc is heated at 110 ℃ and 150 ℃ it will become malleable and ductile. Zinc is a corrosive metal that is extensively employed in corrosion-resistant coatings, alloys, paints, and the burning of fossil fuels, which produces inorganic chemicals such as carbon monoxide (Borah, Kumar & Devi, 2020).

Zinc is an important metal in the industry because it is suitable as a component in certain products such as in galvanizing industry. Zinc can combine with other metals such as copper, tin and zinc also called bronze because they will work well with each other. The combination of zinc and aluminium form can produce high quality components and when copper, nickel, and zinc are mixed, nickel silver will be produced (Sabnavis, et al., 2018). The roof also uses zinc as it is manufacturing material because zinc can protect the roof from rust. The usage of zinc for the galvanization process is to improve the quality of the galvanization process and provide beneficial effects to the galvanized components (Furquim, 2017).

Soil pollution with heavy metals already become a global concern because it contains toxic which is dangerous to humans. The present of zinc in bioavailable forms that cannot surpass a particular quantity or become harmful, such as having a phytotoxic impact if the zinc content is high and lowering crop quality (Alam, et al., 2020). However, zinc is essential to the plants in lower concentrations because if deficient of zinc will lead to another problem. Zinc concentration can increase in the soil due to the activities of mining and metal-contaminated waste sludge.

Zinc has both good and bad effects on human health. Zinc is an essential element in the human body. The deficiency of zinc in the body can lead to disruption of growth and immunity. In the body, zinc can be found in all of the body's organ such as muscle and bone (Hassan, et al., 2020). Zinc assists in insulin production, protein synthesis, development of muscles as well as boosting memory and mental wellness (Bharodia & Patel, 2021). The bad effect of zinc occurs when exposed to zinc at a high concentration. (Bimola Devi, et al., 2020) stated the excessive zinc intake will lead to gastrointestinal effects, such as stomach pain, vomiting, and diarrhoea.

2.4.7 Tin (Sn)

Tin is an element 50, also known as the “Sn” symbol name from Latin which is stannum. For decades, it has been mined all over the world and it is not easy to oxidize in the air. There are two allotropes of metallic tin. First is a malleable silvery-white metal, β-tin is a stable allotrope at room temperature. The second is a grey α-tin that is less dense, available at low temperature, and in the structure of diamond cubic. The characteristics of tin are not easy to obsolete, have unique conductivity, and tend forming alloys. Tin compounds can be used in antifouling paint, PVC pipes, and, most likely, the bones, where tin compounds commonly accumulate (Tarselli, 2017).

The increasing use of tins makes the demand for it high, especially in the manufacturing sector. Tin demand increased, as did people's economies, and large corporations with legal permits from every government faced bankruptcy as the price of tin dropped dramatically on the world market (Ibrahim, 2016). The mix between tin and copper can produce bronze. Tin bronze has high resistance to both hydro abrasive wear and corrosion in high salinity or particularly hostile conditions, so it is suitable in heavy industry and fuel platforms (Nejneru, et al., 2016). In the packaging industry, around a third of the world's tin supply is used to make tin cans, which means food containers have the most various uses (Abdelgayoum Abdelrahman, 2015).

Humans can expose to tin everywhere such as in the environment and food products. Inhalation, ingestion, and skin exposure are also possible ways for humans to be exposed. Ostrakhovitch, (2015) stated food consumption, especially canned foods, and drinks, is considered to be a major cause of inorganic tin exposure in humans. The tin level in canned foods is influenced by several factors such as storage conditions and food acidity but several studies have found no link between canned food consumption and urinary tin levels (Yang, et al., 2015). The symptoms when exposed to tin with long-term exposure are benign pneumoconiosis and stannosis, without indications of fibrosis and lung cancer (Ostrakhovitch, 2015). Stannosis is a radiological diagnosis characterised by a scattering of irregular, thick opacities in the lung fields (Johanna, & Paul, 2019).

2.5 Impact of Heavy Metals to Human

Heavy metal is a toxic metal, mostly, heavy metals are spread in the environment due to the effects of factory waste into the air, water, and soil. Then, humans will feel the effect of contamination due to the inhalation process, food intake, and others. Pb, Cd, and arsenic have caused the most concern in terms of their possible toxic effects on humans since they are easily transported across food chains and are not considered to perform any important biological functions (Ciazela, Siepak, & Wojtowicz, 2018). Cadmium, a contaminant of the atmosphere, is not able to decompose in nature. It has an effect on signal transduction pathways, apoptosis among other cellular processes, and is carcinogenic to the gastrointestinal tract which can lead to cancer (Bishak, et al., 2015). On a global scale, cancer is the leading cause of morbidity, aging, and premature death. WHO, (2021) reported the number of new cases of cancer in Malaysia in 2020 is 48 639 for both sexes and all ages which shows a high number of cases.

Heavy metal is non-degradable and exists in the environment. As a result, it has gotten a lot of attention because of its possible health and environmental threats. Metals can confound regulatory mechanisms like homeostasis, distribution, and binding to specific cell constituents, resulting in toxic and even lethal consequences in the human body (Jan, et al., 2015). A recent study found that exposure to a wide range of metals during the prenatal period is connected to autism spectrum disease, generally known as ASD (Ijomone, et al., 2020). Mercury, arsenic, and lead are categorized as metallic element which is capable of causing toxicity systemic toxicants even at low levels of exposure.

2.6 Impact of Heavy Metal in Food Security

The heavy metal and metalloids could be disturbed the human metabolic system and contribute to morbidity and mortality. The adverse effects of contamination on canned fruits can be threatened food security and human health (Anani, et al., 2020). It is because heavy metals constitute chemical hazards. There are four dimensions of food security which are food availability, food access, utilization, and stability. However, the heavy metal concern is categorized in the utilization dimension of food security (Das, et al., 2019).

The utilization in food security refers to the household's accumulated food, the nutrition and quality of the food in digesting the nutritional of accumulated food (Nicholsan, et al., 2021). This dimension is concerned with a balanced diet, safe drinking water, sanitation, and health care in order to achieve nutritional well-being and meet all physiological requirements. Food processing and preparation are included in food utilization. The heavy metal might occur during the processing and preparation step, so utilization dimension complies with heavy metal in canned fruits product.

The impact of heavy metals in food security especially from canned fruits products has been shown to impact human metabolomics, resulting in a high incidence of morbidity in some nations, particularly in poor countries (Anthony, et al., 2020). The heavy metal which brings dangerous material into the body can lead to various diseases the people.

2.7 Method of Study in Heavy Metal Residue

The determination of heavy metal residue in canned fruits study can be analysed using several analytical methods to the canned fruits samples. Flame atomic absorption spectrometry (FAAS), electrothermal atomic absorption spectrometry (ETAAS), and inductively coupled plasma optical emission spectroscopy (ICP-OES) are some of the techniques available (Arpa & Arıdaşır, 2019). As the digestion for sample canned fruits, the wet digestion method can be used.

Atomic Absorption Spectrometer will function as an analyst to determine the heavy metal contamination in canned fruits samples. The dissolution of canned fruits product samples before elemental analysis is accomplished using wet digestion methods. Before spectroscopic elemental analysis, the majority of samples are immersed in different acids. Wet or acid digestion has the advantage of being beneficial on both organic and inorganic compounds because it destroys the sample matrix and thereby reduces disruption (Uddin, et al., 2016).

2.8 Atomic Absorption Spectrometer (AAS)

Atomic Absorption Spectrometer (AAS) is an easy, high-throughput, and low-cost technology for analysing compounds in solution. It is a quantitative spectro-analytical procedure for the determination of chemical elements using the absorption of optical radiation by free atoms in the gaseous state (Biswas, et al., 2017). It has been used in research of pharmaceutical, clinical, water, and food and beverages. Atomic Absorption Spectrometer (AAS) is also used in mining activities to figure out how much precious metal is in rocks. There are two types of Atomic Absorption Spectrometer (AAS) equipment which are Flame Atomic Absorption Spectrometer (FAAS) and Graphite Furnace Atomic Absorption Spectrometer (GFAAS) (Akaki, Awash, & Fita, 2018).

In the study of heavy metal in canned foods, decomposition of food samples is assumed in atomic spectrometry techniques, which is commonly performed using wet digestion, acid digestion, or dry ashing methods, followed by testing in the flame or graphite furnace mode of AAS or ICP-OES (Ghanjaoui, et al., 2019). A source of external radiation focuses on the analyte vapour in an atomizer in AAS.

The instrumentation of Atomic Absorption Spectrometer (AAS) has three which are atomizer, radiation source and spectrometer. The hollow cathode lamp radiation and monochromator are two examples of atomic absorption instrumentation concepts. The chemical compound of the sample will dissociate into free atoms, and it will accomplish by aspirating a sample solvent through a flame associated with the light beam. Under the correct flame conditions, many atoms will remain in the ground state and will be able to receive light at the analytical wavelength from a source lamp (Yeung, Miller & Rutzke, 2017). The resonance line is a wavelength or spectral line so, the monochromator is in charge of determining the correct wavelength for analysis. Since the monochromator is incapable of isolating a single wavelength, the wavelength spectrum is passed on to the detector (Elwell, & Gidley, 2013). Figure 2.1 shows the schematic diagram of the Atomic Absorption Spectrometer (Bata, et al., 2018).

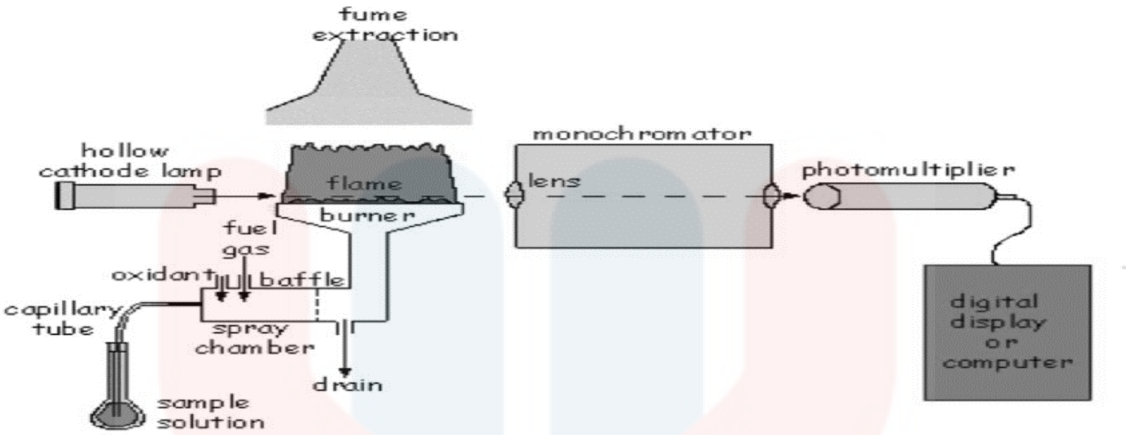

Figure 2.1: The Schematic Diagram of Atomic Absorption Spectrometer (Source: Bata, et al., 2018)

2.9 Health Risk Assessment

Health risk assessment is the fundamental element of personalised medicine that assess a person's overall health and probability of contracting a certain disease (Bregendahl, Orlando, & Palaniappan, 2017). Health risk assessment plays a crucial role in health promotion and disease prevention on both a personal and population basis. Demographics, diet, personal and family health records, and physiological data are also included in the basic health risk assessment data.

There are four main elements in the health risk assessment that need to examine and summarize to get the data which are hazard identification, exposure assessment, dose-response assessment, and risk characterization (Ben, et al., 2019). Hazard identification is the process of determining which chemicals are found in a given area or the product as well as their concentrations and spatial distribution example as Cd, Cr, and Zn are possible heavy metals found in the research area. Exposure assessment aims to determine the level, frequency, and period of human exposure to a contaminant in the environment. The total daily consumption of heavy metals previously detected by absorption, inhalation, and dermal interaction was measured as part of the exposure assessment (Kamunda, Mathuthu, & Madhuku, 2016). Next, dose-response assessment is the estimation of an agent's toxicity or efficacy by assessing the quantitative association between exposure or dose and reaction. Two significant toxicity indicators used are the cancer slope factor (CSF), which is a carcinogen potency factor, and the reference dosage (RfD), a non-carcinogenic threshold. Lastly, the risk characterization is estimating the risk of adverse effects from human exposure also predicts the risk of cancer and non-cancerous diseases in the finding (Dellarco, & Bangs, 2016).

CHAPTER 3

METHODOLOGY

3.1 Analytical Instruments

The concentration of heavy metal residue in selected canned fruits samples was determined by using an Atomic Absorption Spectrometer (AAS) (Perkin-Elmer (PE) 3300). The computer auto-sampler would control AAS during it is operating.

3.2 Chemicals and Reagents

The list of chemicals and reagents that was used in this research study are listed in Table 3.1. All of the chemicals and reagents are analytical grade.

Table 3.1: List of chemicals and reagents

No.	Chemical and Reagents
1.	Hydrogen peroxide (H_2O_2)
2.	Concentrated nitric acid (HNO_3)
3.	Concentrated hydrochloric acid (HCL)
4.	Deionized water
5.	Lead nitrate, $Pb(NO_3)_2$
6.	Chromium nitrate, ($Cr(NO_3)_3 \cdot 9H_2O$)
7.	Zinc nitrate, $Zn(NO_3)_2$
8.	Cadmium nitrate, $Cd(NO_3)_2$
9.	Nickel nitrate $Ni(NO_3)_2$

3.3 Apparatus

The list of apparatus was used in this research is listed in Table 3.2.

Table 3.2: List of laboratory apparatus

No.	Apparatus
1.	Volumetric flask 50 mL
2.	Beaker
3.	Measuring Cylinder 5 mL
4.	Weighing machine
5.	Watch glass
6.	Hotplate
7.	Glass dropper
8.	0.45 mm PTFE filter
9.	Digital heating block
10.	Hallow Cathode Lamp
11	Winlab 32^{TM} AS computer software
12	Atomic Absorption Spectrometry
13	Laboratory fume hood
14	Stainless steel spatula
15	Falcon tube 50 mL

3.4 Collection of Samples

There are four types of canned fruits products were purchased which are longan canned fruits, lychee canned fruits, pineapple canned fruits, and cocktail canned fruits. The canned fruits were purchased from the local market store at Kelantan.

3.5 Preparation of Blank Reagents Solutions

The black reagent solutions were prepared by using 5 mL of nitric acid (HNO_3) and 5 mL of sulphuric acid (H_2SO_4). The mixture of the solution was diluted with deionized water in a 50 mL volumetric flask.

3.6 Preparation of Standard Calibration Solution

The calibration function is to create a response curve by establishing a quantitative relationship between several established concentrations and their corresponding signals (Handayani, et al., 2019). Stock solution for each type of heavy metal which are Pb, Cd, Cr and Zn was prepared at the concentration of 1000 mg/L. Standard calibration solution for each type of heavy metal at concentrations from 5 µg/L to 100 µg/L was prepared by diluting the stock solution of heavy metals with deionized water that contain 15 mL nitric acid (HNO_3), 5 mL of sulphuric acid (H_2SO_4) and 1 mL hydrogen peroxide (H_2O_2).

3.7 Standard Calibration Solution for Cd, Cr, Pb, Ni and Zn

3.7.1 Standard Calibration Solution for Cd

The standard calibration solution of Cd was prepared, a fixed volume of standard stock solution of Cd was diluted with 40 µL of 0.5% v/v nitric acid in a 50 mL volumetric flask and deionized water was used to dilute it to the desired volume. Then, in the AAS method, the Cd concentration range was set between 0.00 mg/L to 0.90 mg/L.

3.7.2 Standard Calibration Solution for Cr

The standard calibration solution of Cr was prepared, a fixed volume of standard stock solution of Cr was diluted with 40 µL of 0.5% v/v nitric acid in a 50 mL volumetric flask and deionized water was used to dilute it to the desired volume. Then, in the AAS method, the Cr concentration range was set between 0.00 mg/L to 4.80 mg/L.

3.7.3 Standard Calibration Solution for Pb

The standard calibration solution of Pb was prepared, a fixed volume of standard stock solution of Pb was diluted with 40 µL of 0.5% v/v nitric acid in a 50 mL volumetric flask and deionized water was used to dilute it to the desired volume. Then, in the AAS method, the Pb concentration range was set between 0.00 mg/L to 7.50 mg/L.

3.7.4 Standard Calibration Solution for Zn

The standard calibration solution of Zn was a fixed volume of standard stock solution of Zn was diluted with 40 µL of 0.5% v/v nitric acid in a 50 mL volumetric flask and deionized water was used to dilute it to the desired volume. Then, in the AAS method, the Zn concentration range was set between 0.00 mg/L to 0.75 mg/L.

3.7.5 Standard Calibration Solution for Ni

The standard calibration solution of Ni was prepared, a fixed volume of standard stock solution of Ni was diluted with 40 µL of 0.5% v/v nitric acid in a 50 mL volumetric flask and deionized water was used to dilute it to the desired volume. Then, in the AAS method, the Ni concentration range was set between 0.00 mg/L to 3.90 mg/L.

3.8 Preparation of Sample

The canned fruits samples (longan, lychee, pineapple, and cocktail) were placed directly in the Petri dish without rinsing it with deionized water. The samples were dried in the food dehydrator at 65 ℃ for 12 hours for longan and lychee while pineapple and cocktail at 65 ℃ for 24 hours. Then, the samples were ground into fine powder by using a blender. The samples were packed in polyethylene zipper bags and ready to proceed with the wet digestion method (Feng, et al., 2018).

3.9 Sample Analysis for Determination of Heavy Metal Residue by Atomic Absorption Spectrometer (AAS)

The wet digestion method was used as a digestion method on Atomic Absorption Spectrometer (AAS) analysis. All of the glassware was soaked in 5% nitric acid for 3 hours then, followed by washing with deionized water. The glassware was dried first before use. All the samples were digested with 5 mL of concentrated nitric acid (HNO_3) and 2 mL of sulphuric acid (H_2SO_4) (Alkhatib & Ataie, 2020).

Firstly, 2 g samples that were already in the powder were weighed and put in a beaker on a hot plate with a magnetic stirrer. The samples were added with 10 mL 1:1 HNO_3 in a beaker and slowly stirred. The beaker was covered with a watch glass and heated the sample to a temperature of 85 ^oC for 15 minutes. After 15 minutes, 5 ml of HNO_3 were added and continued heated for 30 minutes. The 2 ml of HNO_3 was added until the brown fume was given off.

After the brown fume disappeared, 2 mL of deionized water and 10 ml of H_20_2 were added and continued heated at 120 ^oC. The volume was heated until the volume was reduced to less than 5 mL. After achieving volume less than 5 mL, 5 mL of HCL were added and continued heated for 15 minutes. The sample was filtered using two types of filters, there were PTFE filter paper and a 0.45 mL syringe filter. The diluted digestive sample was filtered into 50 mL volumetric flasks and added deionized water until the mark. The samples were put into a falcon tube and made the serial dilution from 10^{-1}, 10^{-2}, 10^{-3}, and 10^{-4} (Ayyıldız et al., 2021). All the samples were prepared to determine Pb, Cd, Cr, Zn, and Ni by using Atomic Absorption Spectrometer (AAS).

3.10 Calculation and Evaluation Result

The concentration of each heavy metal in the sample was calculated by using the equation according to AOAC International (2002) as shown in 3.1 :

$$C = \frac{(a - b) \times V}{m \times 1000} \quad (3.1)$$

Where, C = concentration of test sample (μg/g)

a = Concentration of test solution (μg/L)

b = Average concentration in the blank solutions (μg/L)

V = Volume of test solution (mL)

m = Weight of the test portion.

3.11 Statistical Analysis

The research study was carried out in triplicate and the mean data from the result was analyzed. The concentration of heavy metal residues contained in canned fruits products were expressed in wet weight, µg/g.

3.12 Survey Conduct

The survey was conducted by using Google Forms in questionnaire type and targeting Malaysian residents as the respondents. The survey was comprised of several parts which are demographic, attitude, social norms, and perceived behavior. There were 362 total respondents who answered this survey.

3.13 Health Risk Assessment

3.13.1 Estimated Daily Intake (EDI)

Estimated daily intake (EDI) (µg/kg body weight) of heavy metals in canned fruit products was calculated by using the equation according to Chamannejadian, et al., (2013) as shown in 3.2 :

$$\mathrm{EDI} = \frac{(\mathrm{Cmetal} \times \mathrm{IR})}{\mathrm{BW}} \tag{3.2}$$

Where, Cmetal = Average weighted heavy metal content (µg/g)

IR = Ingestion rate daily canned fruits consumption (gram/day person)

BW= Average body weight

3.13.2 Estimated Weekly Intake (EWI)

Estimated weekly intake (EWI) of heavy metals in canned fruit products were calculated by using the equation according to Borone, et al., (2018) as shown in 3.3 :

$$\mathrm{EW} = \frac{C \times IR}{BW} \tag{3.3}$$

Where, C = Element concentration in canned fruit

IR= Daily ingestion rate (g/day)

BW= Body weight

3.13.3 Target Hazard Quotient (THQ)

Target Hazard Quotient (THQ) was calculated to estimate the non-carcinogenic risk and target carcinogenic risk in canned fruits (Borone, et al.,). The equation as shown in 3.4 :

$$\mathrm{THQ} = \frac{\mathrm{EF} \times \mathrm{ED} \times \mathrm{FIR} \times \mathrm{C}}{\mathrm{RfD} \times \mathrm{BW} \times \mathrm{AT}} \times 10^{-3} \tag{3.4}$$

Where, EF = Exposure frequency for average consumer

ED = Exposure duration (70 years) equivalent to the average human lifespan

IR = Ingestion rate (g/person/day)

MC = Metal concentration in canned fruits (μg/kg,ww)

RESEARCH FLOW CHART

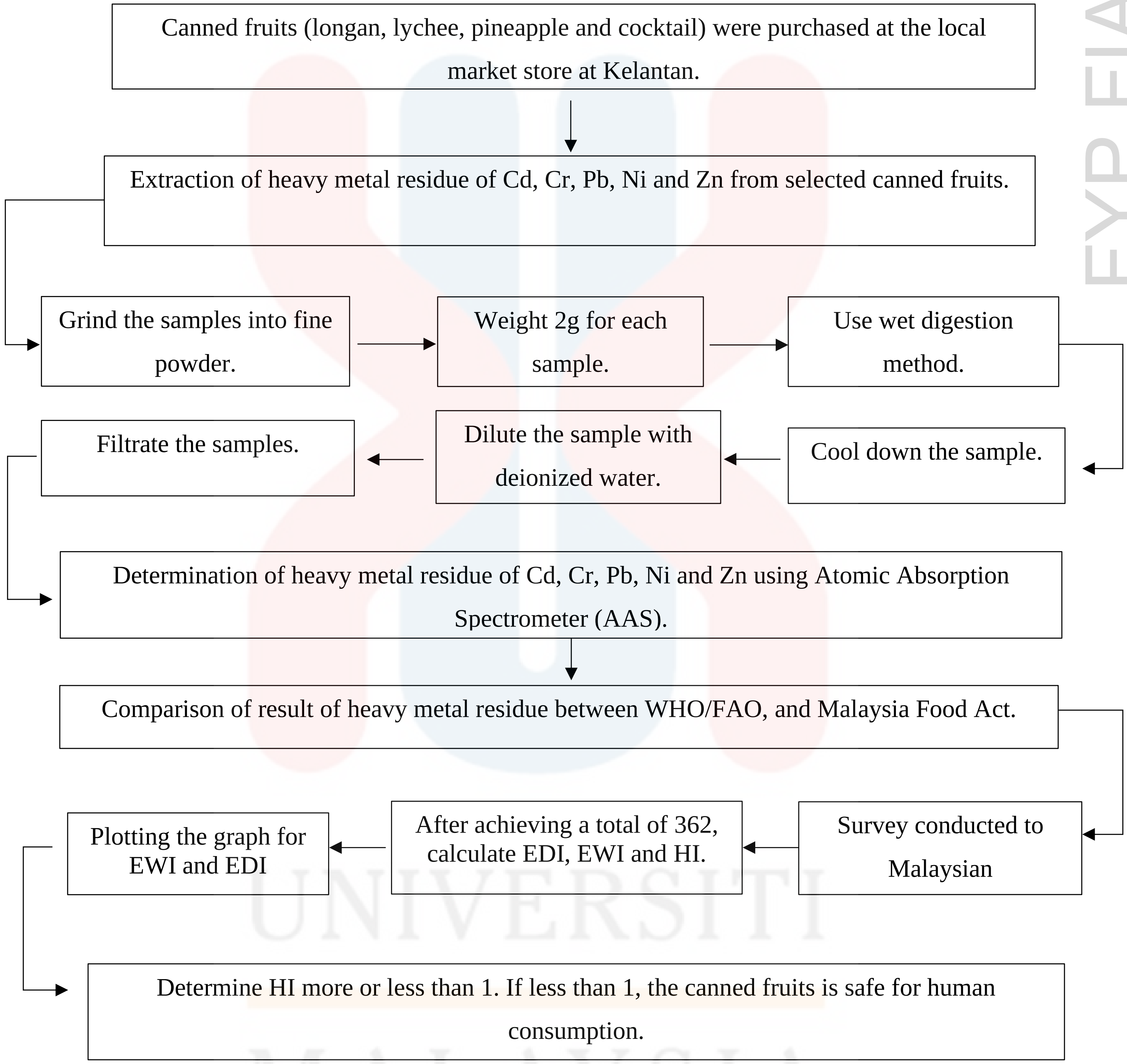

Figure 3.1 : Summarize flow chart of research activities

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Samples Collection

The four types of canned fruits products that were purchased are longan canned fruits, lychee canned fruits, pineapple canned fruits, and cocktail canned fruits. The canned fruits were purchased from the local market store at Kelantan.

4.2 Samples Preparation

Longan, lychee, pineapple, and cocktail samples were placed straight in the Petri plate without being rinsed with deionized water. Longan and lychee samples were dried in a food dehydrator at 65 °C for 12 hours, while pineapple and cocktail samples were dried at 65 °C for 24 hours (Kringel et al., 2020). After that, using a blender, the samples were crushed into a fine powder. The samples were sealed in plastic zipper bags and ready for the wet digesting procedure (Feng, et al., 2018).

4.3 Samples Extraction

The 2 g of powder samples were weighed and placed in a beaker on a heated plate with a magnetic stirrer. In a beaker, the samples were mixed with 10 ml 1:1 HNO_3 and swirled slowly (Asafew & Chandravanshi, 2021). The sample was heated to 85 ^oC in a beaker covered with a watch glass for 15 minutes. After 15 minutes, 5 mL HNO_3 was added, and the mixture was heated for another 30 minutes. The 2 ml of HNO_3 was added until a brown fume emerged.

The 2 ml of deionized water and 10 mL of H_2O_2 were added when the brown fume had gone away, and the mixture was heated at 120 ^oC for another 10 minutes. The heat was applied to the volume until it was reduced to less than 5 mL. After reaching a volume of less than 5 mL, 5 mL of HCL was added and heated for another 15 minutes. Two types of filters were used to filter the sample: PTFE filter paper and a 0.45 mL syringe filter. The diluted digested sample was filtered into 50 mL volumetric flasks and deionized water was added until the desired concentration was reached. In a falcon tube, the samples were serially diluted from 10^{-1} to 10^{-2}, 10^{-3}, and 10^{-4} (Ayyldz et al., 2021). The metals Pb, Cd, Zn, Cr, and Ni were determined by Atomic Absorption Spectrometry after the solution was kept in centrifuge tubes and refrigerated at 2 °C in a chiller (Abrham & Gholap, 2021).

4.4 Metal Concentration in Different Canned Fruits Products

The concentration of cadmium, chromium, nickel, zinc, and lead present in canned fruits products of longan, lychee, pineapple, and cocktail were shown in Table 4.1. The concentration of heavy metals got based on the mean and standard deviation.

The results for the concentration were acquired after putting the samples into the Atomic Absorption Spectrometer to analyse those heavy metals. Based on Table 4.1, the concentration of the samples was compared according to the same type of heavy metal found in the canned fruits products. On a wet weight basic, the measurement used in this concentration was in a unit of a milligram per kilogram (mg/kg).

The concentrations of Cd, Cr, Ni, Zn, and Pb of the canned fruits product showed significant concentrations when compared. Overall, the highest concentration was zinc in lychee canned fruit (0.36 mg/kg) while the lowest concentration was detected in nickel for longan canned fruit (0 mg/kg). From table 4.1, the samples of lychee canned fruit, pineapple canned fruit, and cocktail canned fruit were showed the highest concentration in Pb (0.015 mg/kg), a sample of cocktail canned fruit was highest in Cr (0.035 mg/kg) and Pb (0.144 mg/kg), Ni concentration highest in pineapple canned fruit sample (0.032 mg/kg) and Zn concentrations highest in lychee canned fruit sample (0.36 mg/kg). For the lowest concentration, Cd in longan canned fruit became the lowest (0.012 mg/kg), Cr in lychee canned fruit (0.024 mg/kg), Ni, Zn and Pb in longan canned fruit (0 mg/kg), (0.185 mg/kg) and (0.11 mg/kg).

The concentration based on each canned fruits product showed in lychee canned fruits products, Zn contained the highest concentration (0.36 mg/kg) while the lowest metal was Ni (0.001 mg/kg). For longan canned fruit, the highest concentration was Zn (0.185 mg/kg) while the lowest was Ni (0 mg/kg). The pineapple canned fruit showed the highest in pineapple (0.193 mg/kg) and lowest in Cd (0.015 mg/kg). The canned fruit for the cocktail recorded the highest concentration in Zn (0.265 mg/kg) and lowest in Ni (0.08 mg/kg).

Therefore, the average concentration of heavy metals (Cd, Cr, Ni, Zn, and Pb) found in canned fruits products was calculated and evaluated in mg/kg units. The result after calculation showed Cd: 0.01425 mg/kg, Cr: 0.02875 mg/kg, Ni: 0.01025, Zn: 1.003 mg/kg and Pb: 0.12275 mg/kg. Therefore, the ranking of heavy metal in descending order was Zn > Pb > Cr > Cd > Ni. The heavy metal concentration in the canned fruits products for each of the four samples (longan, lychee, pineapple, and cocktail) produced the same rating. The heavy metals contents in each sample were compared towards the Malaysia Food Act 1983 & Food Regulation 1985 (MFAR) and FAO/WHO (2011) permitted level. All of the heavy metals' concentrations had modest levels that did not exceed the allowed limits from MFAR and FAO/WHO.

Table 4.1: Level of heavy metal concentration (mg/kg) in canned fruits products.

Type of canned fruits products	**Concentration of heavy metal (mg/kg) Mean ± SD**				
	Cd	Cr	Ni	Zn	Pb
Longan	0.015 ± 0.0005	0.024 ± 0.0269	0.001 ± 0.0117	0.36 ± 0.0044	0.117 ± 0.0135
Lychee	0.012 ± 0.0003	0.027 ± 0.0102	n.d*	0.185 ± 0.003	0.11 ± 0.0166
Pineapple	0.015 ± 0.0001	0.029 ± 0.0057	0.032 ± 0.0087	0.193 ± 0.001	0.12 ± 0.0093
Cocktail	0.015 ± 0.0006	0.035 ± 0.0045	0.008 ± 0.0021	0.265 ± 0.0024	0.144 ± 0.016
Permissible limit (MFAR)	1.0	-	-	-	1.0
Permissible limit (WHO/FAO)	0.05	1.0	0.3	30.0	1.5

n.d*: not detected

4.5 Result Analysis of Heavy Metal

4.5.1 Cadmium, Cd

Cadmium is the metal that harmful to human which is categorised as non-essential hazardous transition metal. All the Cd concentrations in each sample resulted low in this studied based on Figure 4.1. The canned fruits products of lychee, pineapple and cocktail were same concentration which are 0.015 mg/kg and longan canned fruits is 0.012 mg/kg. Due to the small amount concentration of the Cd in canned fruits products, Atomic Absorption Spectrometer (AAS) hardly analyse the result of Cd. The permissible limit that set by MFA (1985) and WHO/FAO are 1.0 mg/kg and 0.05 mg/kg, respectively. This showed the concentration of Cd in lychee canned fruits, longan canned fruits, pineapple canned fruits and cocktail canned fruits were still below the permissible limit set by MFA and WHO/FAO.

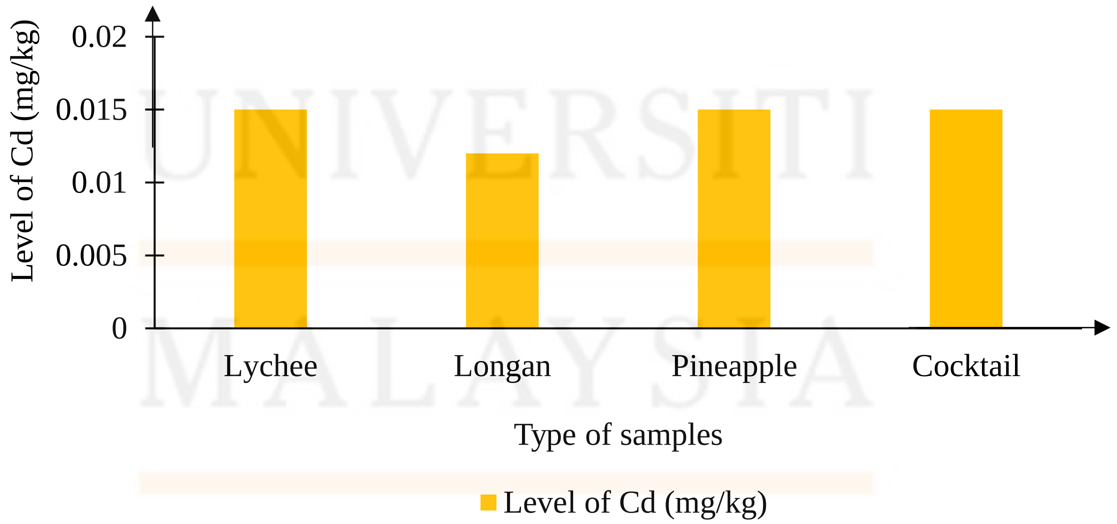

Figure 4.1: Concentration of cadmium (Cd) in canned fruits products.

Based on Table 4.2, it is shown that the canned fruits products were studied is not exceed the permissible limit of MFA (1985) and WHO/FAO (2011) for the concentration of Cd in those products and resulted in the low concentration. Pineapple canned fruits resulted as the highest mean and standard deviation which is 0.015 ± 0.0001 mg/kg followed by lychee canned fruits which are 0.015 ± 0.0005 mg/kg and cocktail canned fruits which are 0.015 ± 0.0006 mg/kg. The lowest is longan canned fruits that result in 0.012 ± 0.0003 mg/kg. Importantly, none of the canned fruits products resulted exceeded the regulatory permitted limits, as the Cd concentrations were negligible by the AAS.

Table 4.2: Comparison concentration of cadmium (Cd) in canned fruits products with the maximum permissible limit set by regulations.

Type of canned fruits products	**Concentration of Cd (mg/kg) Mean ± SD**	**Maximum permissible limit of Cd**	
		MFA (1985)	**WHO/FAO (2011)**
Lychee	0.015 ± 0.0005	1.0	0.05
Longan	0.012 ± 0.0003	1.0	0.05
Pineapple	0.015 ± 0.0001	1.0	0.05
Cocktail	0.015 ± 0.0006	1.0	0.05

Based on the study conducted by Rusin et al., (2021), the concentration of Cd in canned fruits products was recorded as low which only ranged from 0.0004 mg/kg to 0.003 mg/kg. That study also showed that the results were below the permissible limit by regulations. However, the study by Akaki, Awash & Fita (2018) showed the concentration of Cd in canned fruits products from the supermarket in Akaki, Ethiopia was high. The range was about 0.2 mg/kg until 0.26 mg/kg because of the industrial waste that contaminates that area. It also same with the research by Ghuniem, Souaya, & Khorshed (2019), the concentration of Cd in canned fruits products was on average 0.3 mg/kg for six samples of canned fruits which means the high amount of Cd concentration that exceeds the permissible limit by WHO/FAO. These previous studies proved that canned fruits product in this research resulted in a lower Cd concentration than usual due to several factors such as the proper and hygiene handling process during the canning process (Saavendra et al., 2019).

4.5.2 Chromium, Cr

Chromium compounds are heavy metals that are known as very poisonous and carcinogenic also can give health effects on the body. Based on Figure 4.2, the concentration of Cr in all canned fruits products resulted in a low limit. The highest Cr concentration is in cocktail canned fruits which is 0.035 mg/kg, followed by pineapple canned fruits (0.029 mg/kg) and lychee canned fruits (0.027 mg/kg). Longan canned fruits contain the lowest Cr among others which is 0.024 mg/kg. The permissible limit regulation only refers to WHO/FAO (2011) because in MFA (1985) no specified permissible limit was found. The permissible limit set by WHO/FAO (2011) for Cr concentration in canned fruits is 1.0 mg/kg. Therefore, the concentration of Cr in this study for lychee canned fruits, longan canned fruits, pineapple canned fruits, and cocktail canned fruits are still under the permissible limit referred by WHO/FAO (2011).

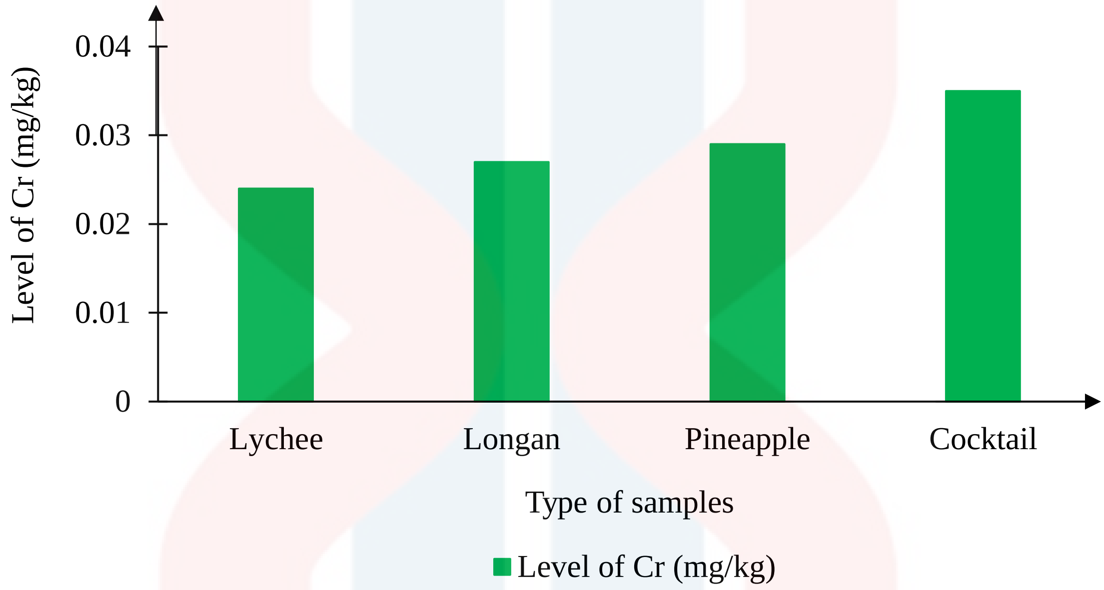

Figure 4.2: Concentration of chromium (Cr) in canned fruits products.

All the canned fruits products in this study resulted as not exceeding the permissible limit of WHO/FAO (2011) for Cr which was 1.0 mg/kg even each Cr concentration in the sample of canned fruits were differ each other. Table 4.3 showed the mean and standard deviation of the canned fruits products for Cr concentration. The highest mean and standard deviation was cocktail canned fruits was 0.035 ± 0.0045 mg/kg. The second highest was pineapple canned fruits which are 0.029 ± 0.0057 mg/kg, followed by longan canned fruits which are 0.027 ± 0.0102 mg/kg, and lastly was 0.024 ± 0.0269 mg/kg.

Table 4.3: Comparison concentration of chromium (Cr) in canned fruits products with the maximum permissible limit set by regulations.

Type of canned fruits products	**Concentration of Cr (mg/kg) Mean ± SD**	**Maximum permissible limit of Cr**	
		MFA (1985)	**WHO/FAO (2011)**
Lychee	0.024 ± 0.0269	-	1.0
Longan	0.027 ± 0.0102	-	1.0
Pineapple	0.029 ± 0.0057	-	1.0
Cocktail	0.035 ± 0.0045	-	1.0

This study resulted in a lower concentration of Cr in canned fruits products if compared to the previous studies. As proven, the concentration of Cr in canned fruits resulted as 1.40 mg/kg to 1.70 mg/kg in the study handled by Ojezele et al., (2021) conducted in South-west Nigeria which showed the level of Cr was exceed the permitted limit by FAO/WHO (2011). The level of Cr in canned fruits from the study located at Jordan also recorded the highest in that heavy metal which is 0.81 mg/kg to 2.43 mg/kg (Altarawneh, 2019). Only one sample of canned fruits from that study showed the lowest which is 0.81 mg/kg while the other level already exceeded the permissible limit by WHO/FAO. After compared with the past studies, the concentration of Cr in this study was much lower.

4.5.3 Nickel, Ni

Nickel is a heavy metal that is prevalent in the environment at extremely low amounts and emitted into the atmosphere by industrial operations. In this study, Ni was found in each sample except for longan canned fruits. The nickel concentration did not result as high as other toxic metals in this study especially if compared with the zinc concentration and lead concentration. From Figure 4.3, pineapple canned fruits were contenting the highest Ni which is 0.032 mg/kg followed by cocktail canned fruits which is 0.008 mg/kg, and lychee canned fruits which is 0.001 mg/kg. For the longan canned fruits, Ni was not detected in this sample. AAS cannot read Ni concentration in that sample until it got 0 mg/kg. That was means the Ni concentration in longan canned fruits does not have or it just has a small amount in that sample. Therefore, all the canned fruits products were below the permissible limit set by WHO/FAO (2011) which is the maximum limit was 0.3 mg/kg. However, the permissible limits set by the MFA (1985) were not specified, so comparisons were only between WHO/FAO (2011).

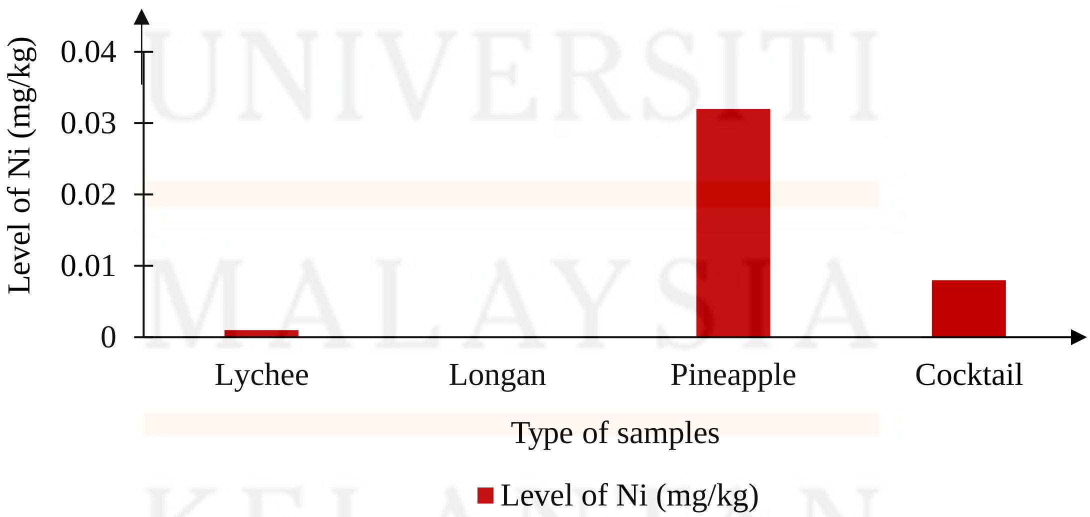

Figure 4.3: Concentration of nickel (Ni) in canned fruits products.

Table 4.4 showed Ni was below the concentration of permissible limit by WHO/FAO (2011) which is all the canned fruits products did not exceed 0.3 mg/kg. The mean and standard deviation of pineapple canned fruits was the highest in this concentration which is 0.032 ± 0.0087 mg/kg. The second was cocktail canned fruits which are 0.008 ± 0.0021 mg/kg followed by lychee canned fruits which are 0.001 ± 0.0117 mg/kg. The lowest was longan canned fruits which are not detected. As a result, all the canned fruits products that through this study was a low concentration of Ni.

Table 4.4: Comparison concentration of nickel (Ni) in canned fruits products with the maximum permissible limit set by regulations.

Type of canned fruits products	Concentration of Ni (mg/kg) Mean ± SD	Maximum permissible limit of Ni	
		MFA (1985)	WHO/FAO (2011)
Longan	0.001 ± 0.0117	-	0.3
Lychee	n.d*	-	0.3
Pineapple	0.032 ± 0.0087	-	0.3
Cocktail	0.008 ± 0.0021	-	0.3

n.d*: not detected

The previous study conducted by Massadeh & Al-Massaedh (2017) showed Ni concentration in the range between 0.97 mg/kg to 2.94 mg/kg from the samples of canned fruits products imported to Jordan. The comparison between the Ni concentration in this study and the previous study was highly different. This resulted in a very low concentration than the previous study. There also have a study that stated that made the research in 10 samples of canned fruits. The results showed only four from that samples were below the permissible limit which the value was 0.2 mg/kg in that samples, others exceeded the permissible limit by WHO/FAO (Fatima, Khan & Shuaib Kabeer, 2021). As the Ni concentrations were barely detectable by AAS instruments, this heavy metal was exceeding the permitted limits indicated in rules by WHO/FAO (2011). That was the reason for the difference in Ni concentration in the past study that resulted in a very significant result.

4.5.4 Zinc, Zn

Zinc is a heavy metal that is both necessary for human health and beneficial in industrial activities. The concentration of Zn in the canned fruits products was quite high but it still does not exceed the permissible limit by WHO/FAO (2011) which is 30.0 mg/kg while MFA (1985) does not have any permissible limit stated by that regulation. Figure 4.4 showed the highest Zn concentration was in lychee canned fruits (0.36 mg/kg), followed by cocktail canned fruits and pineapple canned fruit which are 0.265 mg/kg and 0.193 mg/kg respectively. The lowest Zn concentration was longan canned fruits which are 0.185 mg/kg. This shows all canned fruits products still below the permissible limit set by WHO/FAO.

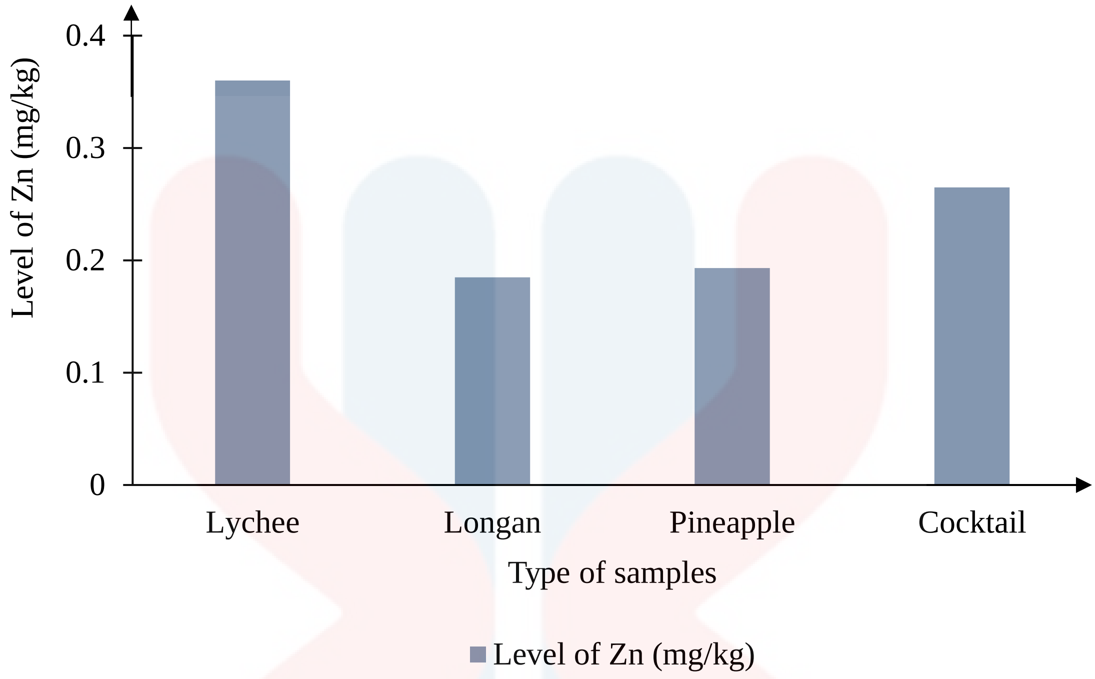

Figure 4.4: Concentration of zinc (Zn) in canned fruits products.

The concentration of Zn metal was low and did not exceed the permissible limit by FAO/WHO (2011) in all canned fruits products based on Table 4.5. Lychee canned fruits resulted as the highest Zn concentration of mean and standard deviation which is 0.36 ± 0.0044 mg/kg. The second was cocktail canned fruits which is 0.265 ± 0.0024 mg/kg, the third was pineapple canned fruits 0.193 ± 0.001 mg/kg. Lastly was longan canned fruits 0.185 ± 0.003 mg/kg. This showed all the canned fruits products in this study were below the permissible limit which is 30.0 mg/kg set by WHO/FAO (2011).

Table 4.5: Comparison concentration of zinc (Zn) in canned fruits products with the maximum permissible limit set by regulations.

Type of canned fruits products	**Concentration of Zn (mg/kg) Mean ± SD**	**Maximum permissible limit of Zn**	
		MFA (1985)	**WHO/FAO (2011)**
Lychee	0.36 ± 0.0044	-	30.0
Longan	0.185 ± 0.003	-	30.0
Pineapple	0.193 ± 0.001	-	30.0
Cocktail	0.265 ± 0.0024	-	30.0

Zn is important for humans and functions in boosting the immune system of the body. The study by Mohd Azizi et al., (2019) showed the concentration of Zn was ranging from 0.012 mg/L to 0.017 mg/L in the canned fruits samples and 6.54 mg/L in canned fruits of longan also has reported by Ang (2019) in his study. Kandil et al., (2020) in the previous study stated that zinc was contained the lowers limit in canned fruits ranged from 1.0 mg/kg to 3.3 mg/kg. The production of zinc in the body was also important because of the advantages. The permissible limit set by WHO/FAO (2011) was high which is 30.0 mg/kg because zinc did not give a huge impact such as cadmium and lead, but it will give an impact if the excessive intake of zinc into the body (Karimi et al., 2021). As a result, zinc is classified as both a necessary element and a harmful metal. Therefore, after compared with the previous studies, zinc concentration in canned fruits products is normal below than permissible limit by WHO/FAO because zinc did not very dangerous to the health when consuming the right intake level.

4.5.5 Lead, Pb

Lead is a very poisonous metal that is frequently used which can cause chaos in the environment and harm people's health. The concentration of Pb from canned fruits products showed in Figure 4.5. The highest concentration of Pb resulted in cocktail canned fruits which is 0.144 mg/kg. The pineapple canned fruits become the second highest which is 0.12 mg/kg value of Pb concentration followed by lychee canned fruits that contained 0.117 mg/kg of Pb concentration. The lowest Pb concentration was in longan canned fruits which are 0.11 mg/kg. Pb concentrations were the second highest among the five heavy metals studied in this study after zinc. However, it is still below the permissible limit because MFA (1985) set the permissible limit for Pb was not exceed 1.0 mg/kg and WHO/FAO (2011) did not exceed 1.5 mg/kg.

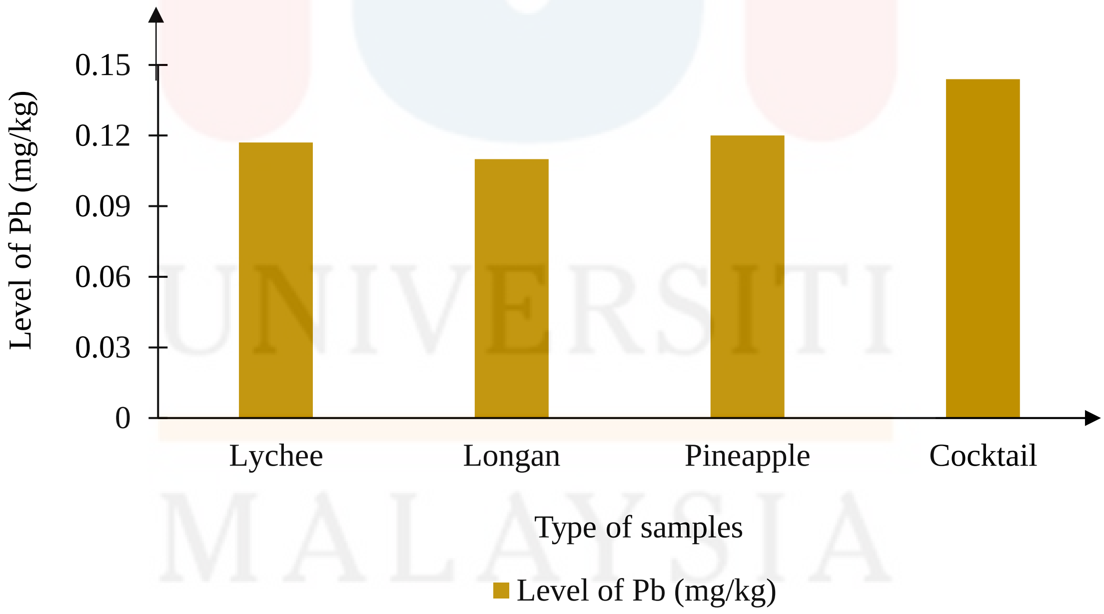

Figure 4.5: Concentration of lead (Pb) in canned fruits products.

The result in Table 4.6 recorded that all canned fruits products in this study had Pb concentration but below the permissible limit by WHO/FAO (2011) and MFA (1985). The mean and standard deviation of Pb concentration was highest in cocktail canned fruits which are 0.144 ± 0.016 mg/kg. The second highest in pineapple canned fruits is 0.12 ± 0.0093 mg/kg. The third was lychee canned fruits which are 0.117 ± 0.0135 mg/kg and lastly was longan canned fruits which are 0.11 ± 0.0166 mg/kg. The results were categorised as the low concentration in Pb because did not achieve the maximum permissible limit which is 1.0 mg/kg in MFA (1985) and 1.5 mg/kg in WHO/FAO (2011).

Table 4.6: Comparison concentration of lead (Pb) in canned fruits products with the maximum permissible limit set by regulations.

Type of canned fruits products	**Concentration of Pb (mg/kg) Mean ± SD**	**Maximum permissible limit of Pb**	
		MFA (1985)	**WHO/FAO (2011)**
Lychee	0.117	1	1.5
Longan	0.11	1	1.5
Pineapple	0.12	1	1.5
Cocktail	0.144	1	1.5

The previous study conducted by Ang (2019) showed the concentration of Pb in canned fruits product which is in longan canned fruits was high (22.65 mg/L) also same from the study by Massadeh & Al-Massaedh (2017) where the range of Pb concentration was from 2.6 mg/kg to 3.0 mg/kg. However, there also result from that showed Pb concentration was low from the permissible limit set by WHO/FAO which is ranging from 0.0008 mg/kg to 0.0099 mg/kg which is researched by Diviš et al., (2017). From those studies, the highest concentration of Pb in canned fruits is due to the lead that is used in processing products that might contaminate those canned fruits. The Pb concentration also can be low in canned fruits products because the contamination was high in can metal. It also became the reason for the low concentration of Pb in this study.

4.6 Accretion of Heavy Metal in Canned Fruits Product

In this study, the evaluation of heavy metal concentration in canned fruits products which are longan canned fruits, lychee canned fruits, pineapple canned fruits, and cocktail canned fruits was one of the objectives to achieve through this study. The health risk assessment also needs to identify in this study to see the risk of heavy metals to humans and the right diet needed to consume it to avoid sickness. The canned fruits products chosen were longan, lychee, pineapple, and cocktail because the people in Malaysia easy to get, familiar, and delicious with taste sweet. Those fruits are consumed by most Malaysians.

By carrying out this research study, it aids in identifying the number of heavy metals in canned fruits products because the fruits were important in the body. The canned fruits products were widely used either as food or made as a side drink because it was easy to prepare and save time. The canned fruits products were the one of packaging process that used the inner coating of cans to pack the product (Almeida et al., 2018). Therefore, the potential of heave metal to contaminate the canned fruits were high so, it was important to make this research for identifying the concentration of heavy metals in canned fruits products and whether the quantities of heavy metal was below or exceed the permissible limit by WHO/FAO (2011) and MFA (1985).

4.7 Survey Conducted

This survey aims to evaluate human health risks in the consumption of canned fruits in Malaysia. This survey is focusing on Malaysian people which is to study their knowledge and perceptions towards the canned fruits product in Malaysia. The total number of respondents who answered this survey was 362 respondents from all of Malaysia from the peninsular to Sabah, Sarawak, and Labuan. The survey is available in google form type and it was disseminated through various social media applications including Whatsapp, Telegram, Facebook, and Instagram in a month and a half. Through this survey, it can get the data to determine the health risk assessments of canned fruits products and their consumption towards these products. The respondents must answer all three parts of this survey which are demographic information, general knowledge towards the heavy metal, and frequency of canned fruits product consumption. The questions survey is set up in multiple-choice questions and available in two languages, English and Malay to make the respondents answer it easily.

4.7.1 Socio Demographic of Respondents

4.7.1.1 Gender of respondents

The socio demographic questions start with the gender of respondents. Figure 4.6 shows the number of respondents either male or female who answered this survey. There is 362 overall total of respondents who are female answer this survey is 221 respondents and 141 respondents are male. The percentage of each gender is 61% from female and 39% from the male. This shows most females were participating in answering this survey after dissemination. This is because females more prefer to answer the survey on the online platform.

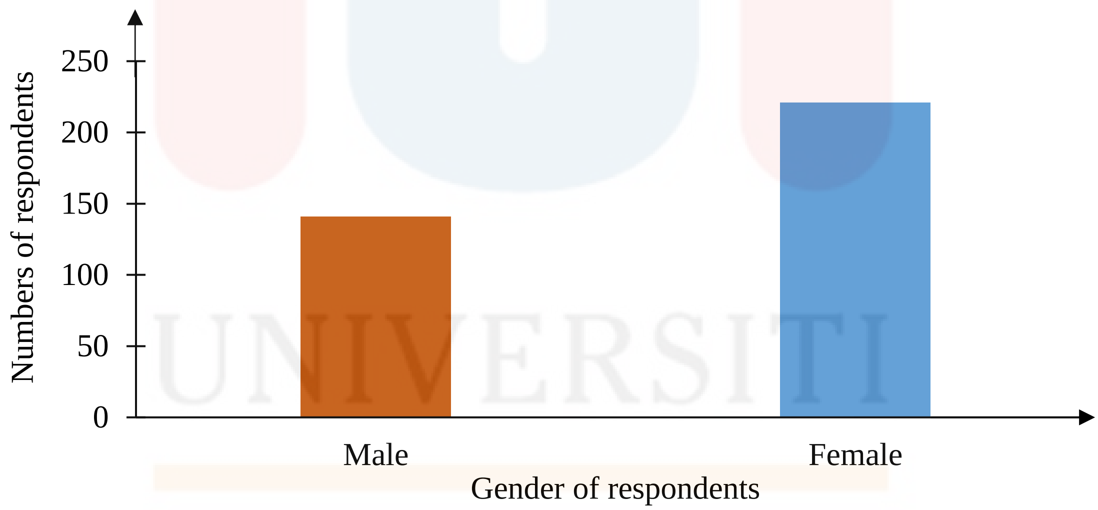

Figure 4.6: Gender of respondents

4.7.1.2 Race of respondents

The race of respondents is the second question in this survey. Figure 4.7 shows the data of respondents in the race part. The respondents involved in this survey were Malay followed by Indian, Chinese, Iban, Kadazan, Bumiputera Sabah, and Dutch. There are 257 respondents were Malay, 52 respondents were Indians, and 45 respondents were Chinese. Malay respondents contribute 71% percentage from overall this survey, Indians were 14.4% percentage, and 12.4% percentage were Chinese. 4 respondents were Iban which contribute 1.1% and Kadazan has 2 respondents. Both Bumiputera Sabah and Dutch only have 1 respondent each. Based on this data, Malay were the highest race in answer this survey because the majority of Malay answered this survey.

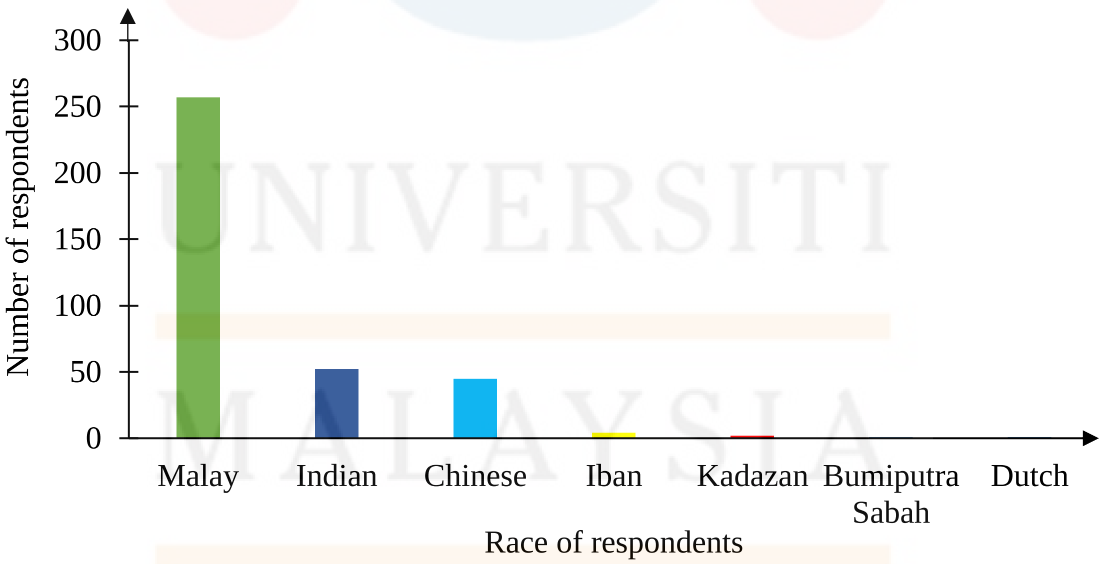

Figure 4.7: Race of respondents.

4.7.1.3 Age of respondents

Figure 4.8 shows the data for the age of respondents. The age was divided into five categories starting with below 20 years old, 21-30 years old, 31-40 years old, 41-50 years old, and more than 50 years old. The highest respondents came from the categories 21-30 years old which is 179 respondents, followed by more than 50 years old which is 60 respondents. The least respondents came from categories aged below 20 years old which is only 27 respondents. The age from 31-40 years old have 52 respondents, contribute 14.4% and the age from 41-50 years old have 44 respondents which are 12.2%. The respondents from 21-30 years old contribute 49.4% in overall the survey, more than 50 years old contribute 16.6% and the least respondents got 7.5% which is from below 20 years old. The categories aged from 21-30 years old became the highest respondents because more people in this age categories use media social.

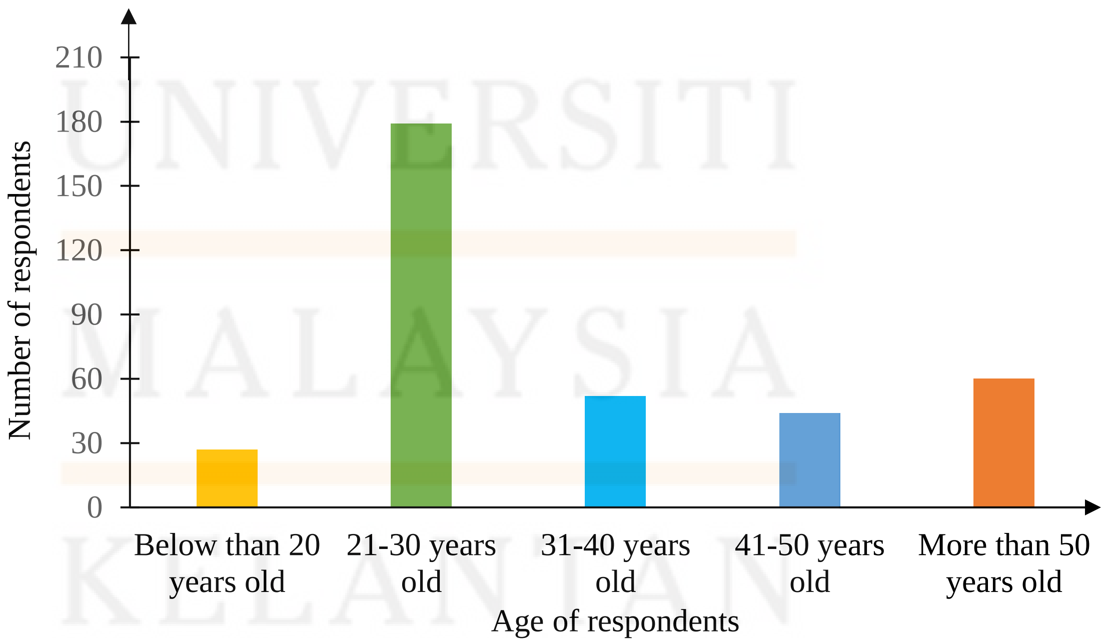

Figure 4.8: Age of respondents

4.7.1.4 Educational Level of respondents

Next, the educational level of respondents is also important to analyse the survey because it can show the result which educational level know more about health risks and consume the canned fruit products monthly. Figure 4.9 shows the data for the educational level of respondents. Based on this survey, most respondents from background Degree which is 141 respondents contribute 39% from overall respondents. Respondents who have background SPM is second highest which is 99 respondents contribute 27.3% and followed by Diploma background which is 77 respondents, STPM background has 30 respondents. 2.8% of respondents have a Master, 0.8% of respondents have a PhD, and 0.6% of respondents are from Primary School backgrounds. The respondents with have Degree background become the most respondents that answer this survey because this survey is more widely distributed to university students.

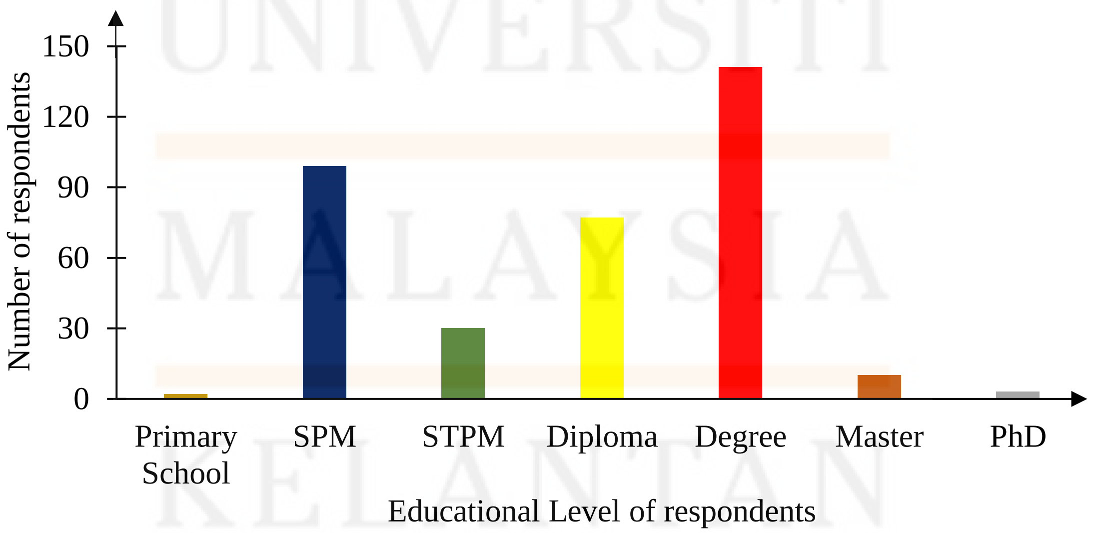

Figure 4.9: Educational level of respondents

4.7.1.5 Monthly Income of respondents

The monthly income of respondents is classified into 11 categories shown in Figure 4.10. The monthly income from respondents is important in this survey to know which group income more bought canned fruits products. Most respondents have an income of less than RM 1000 which is 107 respondents and contribute 29.6% from the survey. 21.5% which is from 78 respondents has income RM 1000- RM 2000 monthly, 16.9% which is from 61 respondents has income RM 2001-RM 3000, and 15.5% which is 56 respondents has income RM 3001-RM 4000. The respondents with a monthly income RM 4001-RM 5000 do not have too much difference with respondents who has income RM 5001-RM 6000. The respondents with RM 4001-RM 5000 income have 21 respondents contribute 5.8% and the respondents with income RM 5001-RM 6000 have 19 respondents contribute 5.2%. There is only has one respondent which has an income of RM 9001-RM 10000 that contributes 0.6%.

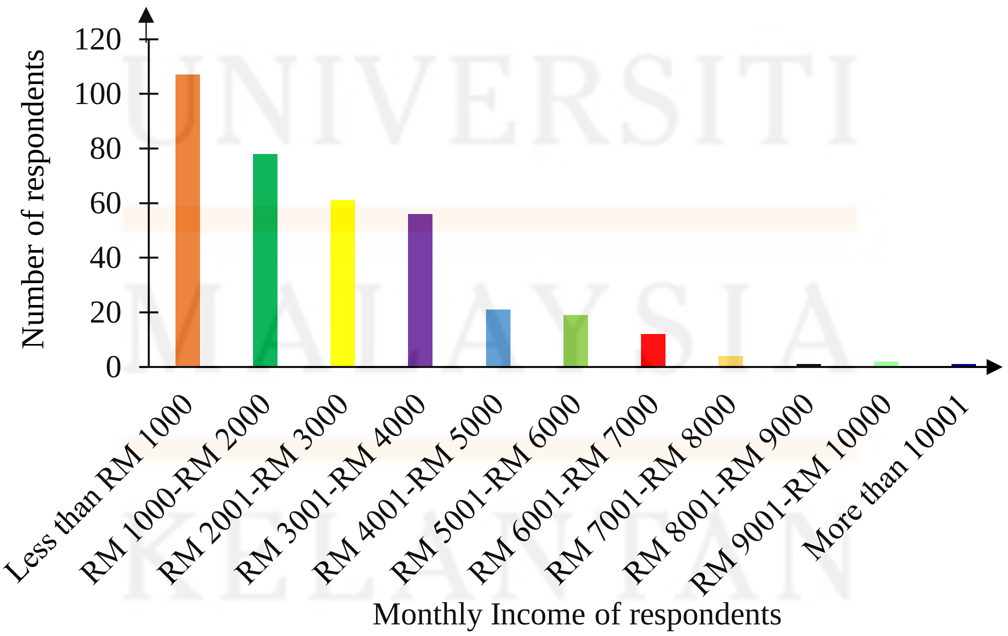

Figure 4.10: Monthly Income of respondents

4.7.1.6 State of respondents

The state of respondents shown in Figure 4.11 is the last question in socio demographic part of the survey. The state is shown where the respondents live. Each state has respondents who answered this survey. There are 13 states and 3 federal territories in Malaysia that include in this survey. Most respondents from Johor which is 121 respondents contribute 33.4% from this survey followed by respondents from Negeri Sembilan which is 35 respondents contribute 9.7% and respondents live in Kuala Lumpur which is 28 respondents contribute 7.7%. The respondents from Melaka just have slightly less than respondents in Kuala Lumpur that are 7.5% equal to 27 respondents who answer this survey. 6.9% of respondents came from Perak, 6.6% of respondents from Kelantan, and 6.4% of respondents from Selangor. Then, 6.1% of respondents from Pahang, 4.1% of respondents came from Terengganu, and 3.9% from Kedah. The respondents from Perlis contribute 3.3% and Sabah's respondents have 1.9%. The respondents from Sarawak and Pulau Pinang are equal which is only 4 respondents each state contributes 1.1% each. However, Labuan and Putrajaya did not have any respondents who came from there.

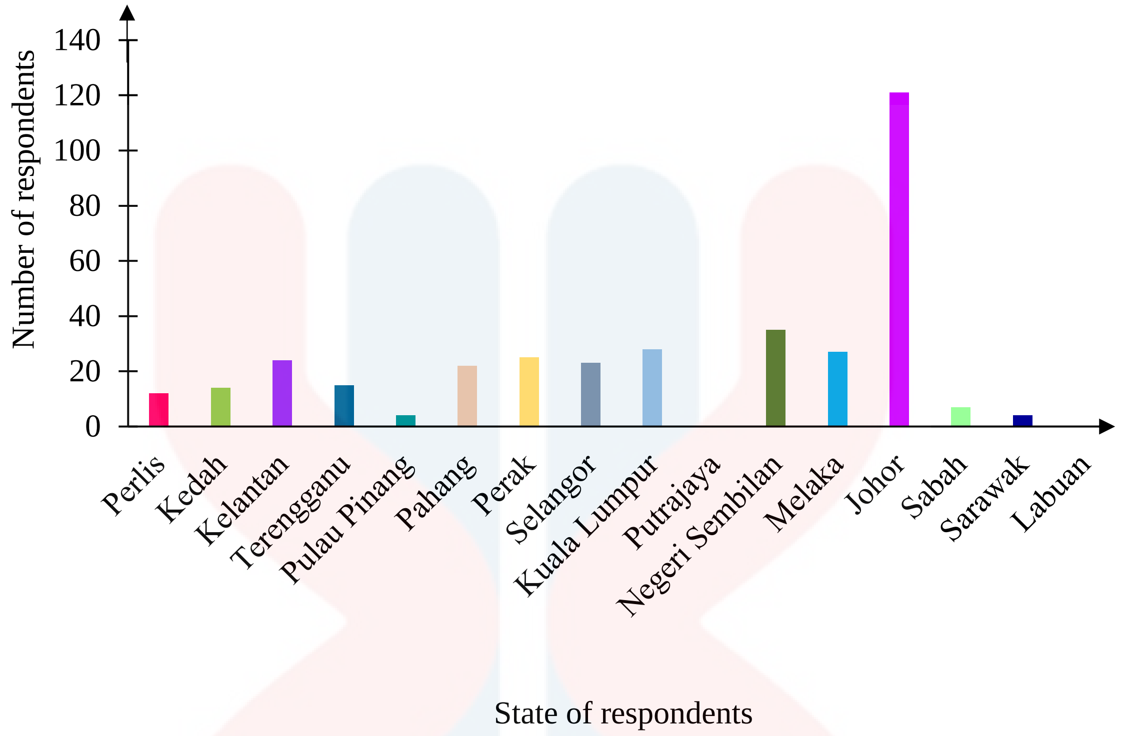

Figure 4.11: State of respondents

4.7.2 General Knowledge of respondents towards Heavy Metal

4.7.2.1 Understand with the term of heavy metal

The first question asked to the respondents in this part which is to know the respondent's general knowledge towards heavy metal is the one shown in Figure 4.12. From the data, most respondents acknowledge and are familiar with heavy metal. 305 respondents answered yes contributing 84.3% while only 57 respondents contribute 15.7% for the question on respondent's knowledge of heavy metals. This means that most respondents already know the term heavy metal either in general or specifically.

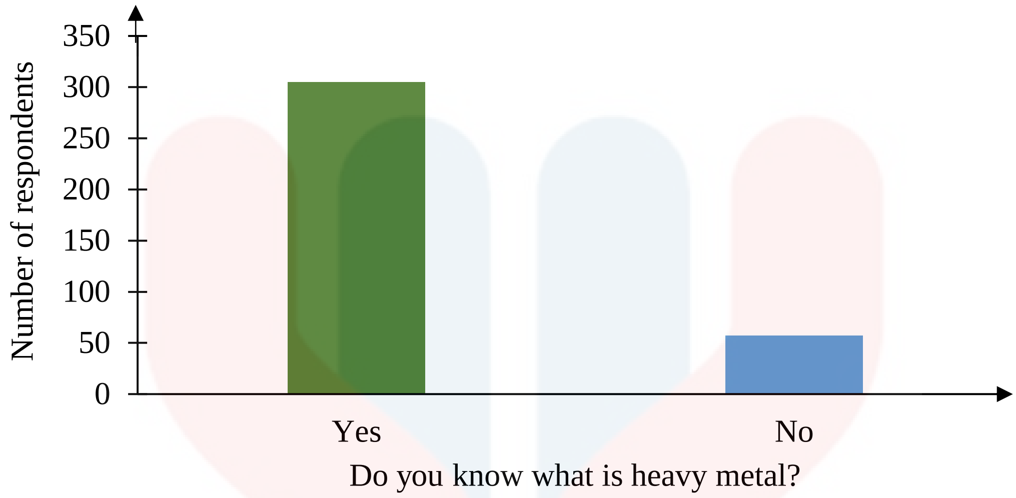

Figure 4.12: Respondents' knowledge towards heavy metal terms

4.7.2.2 Opinion with The Meaning of Heavy Metal

The question about the meaning of heavy metal is the second question in this part. Figure 4.13 shows the data about the understanding of heavy metal to the respondents. There are four answer choices that respondents can choose to find the fit meaning of heavy metal that the respondents understand. 156 respondents chose high density and toxic at low concentration as their answer which contributes 43.1%. The answer on high density and toxic at high concentration has been chosen by 134 respondents contribute 37%. Low density and toxic at high concentration have been answered by 10.2% which is 37 respondents and low density and toxic at low concentration have been answered by 35 respondents. Based on this result, it shows most respondents understand the right meaning of heavy metal which is high density and toxic at low concentration while the respondents that answered high density and toxic at high concentration might be confused about what heavy metal is.

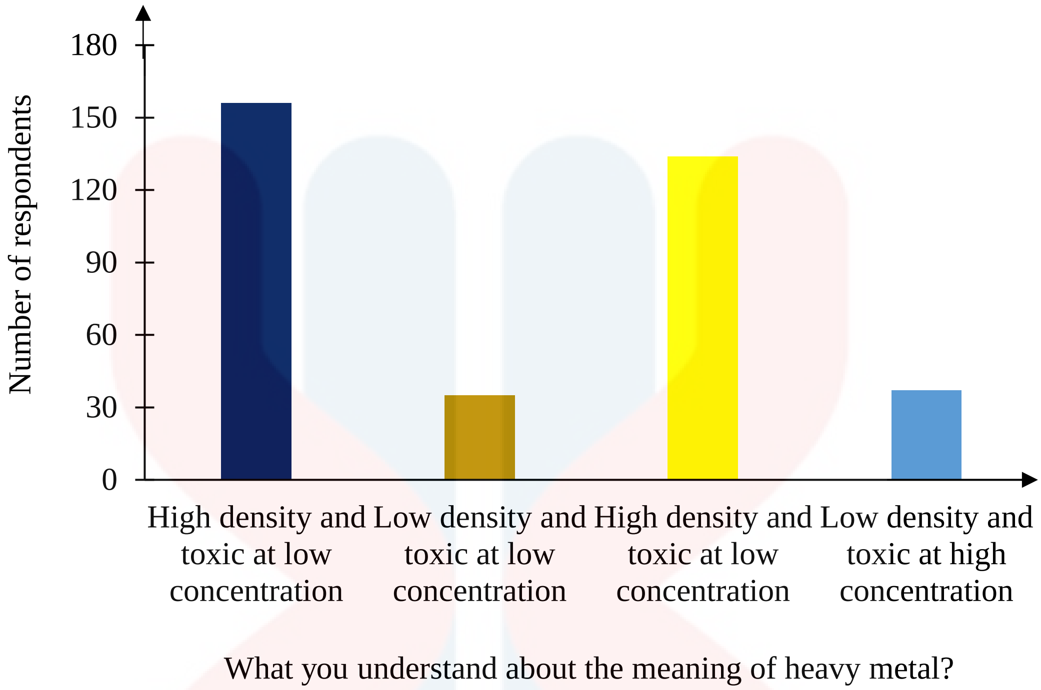

Figure 4.13: Respondents’ opinion towards heavy metal meaning

4.7.2.3 Knowledge about Heavy Metal in Food

The third question in this part which is in Figure 4.14 is to find out the knowledge of respondents to the heavy metal in the foods. The questions are given in the form of statements which is the statement of the heavy metal also present in the food. From these statements, 313 respondents contribute 86.5% answered yes while others which is 49 respondents answered no. This means most respondents acknowledge that heavy metal is also presented in the food not only in water and soil.

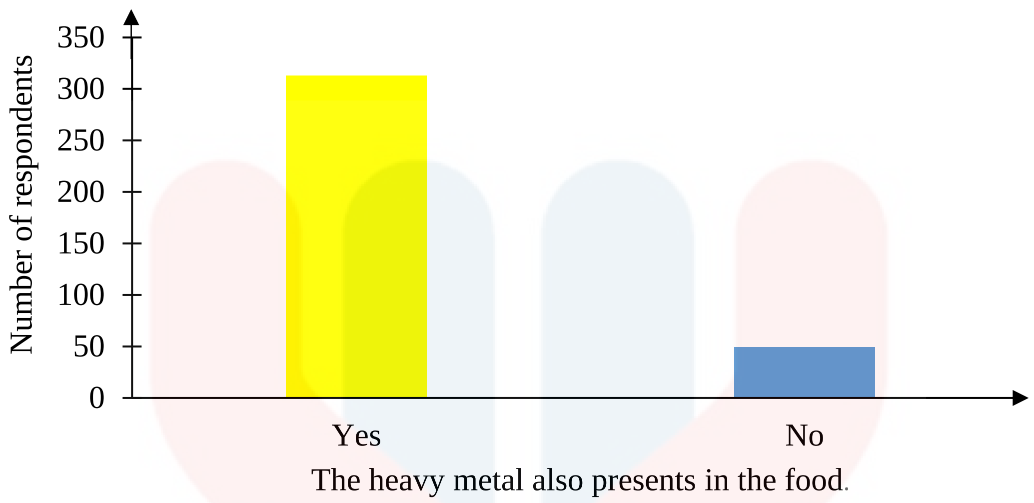

Figure 4.14: Respondents' knowledge towards heavy metal in food

4.7.2.4 Knowledge on Example of Heavy Metal

Next, Figure 4.15 shows the statements about examples of heavy metal. The examples of heavy metals given in the statements are zinc (Zn), lead (Pb), and tin (Sn). The result from this question shows 350 from 362 respondents answered yes while the other 12 answered no. This shows 96.7% of respondents are already familiar with the type of heavy metal and know the heavy metal in the environment. The other 3.3% of respondents might be familiar with another type of heavy metal or not ever know the name of heavy metal.

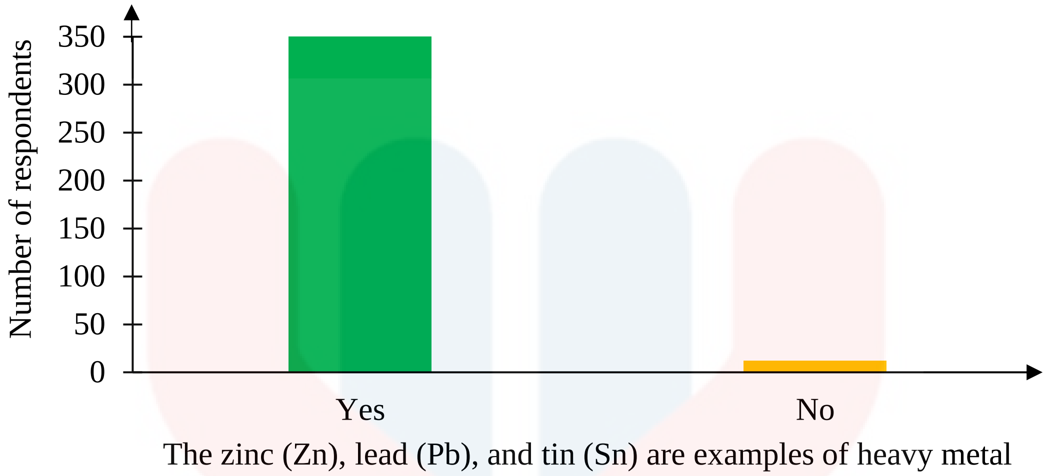

Figure 4.15: Respondents' knowledge towards example of heavy metal

4.7.2.5 Knowledge about Heavy Metal in Canned Fruits Product

After that, Figure 4.16 is about to acknowledge either respondent know about the heavy metal in canned fruits product. This question has been asked in yes or no types answer to make the respondents easily make their choices to answer it. The question is asked either the respondents knows that the canned fruits product exposed to heavy metal. 82.6% which is 299 from 362 respondents answered yes to these questions. Most respondents already know the canned fruits product exposed to heavy metal. These respondents may know these facts through reading as well as television, social media, and online platforms. However, 63 respondents answered no in this question. This could be because the respondents are not exposed to facts about heavy metals in canned products.

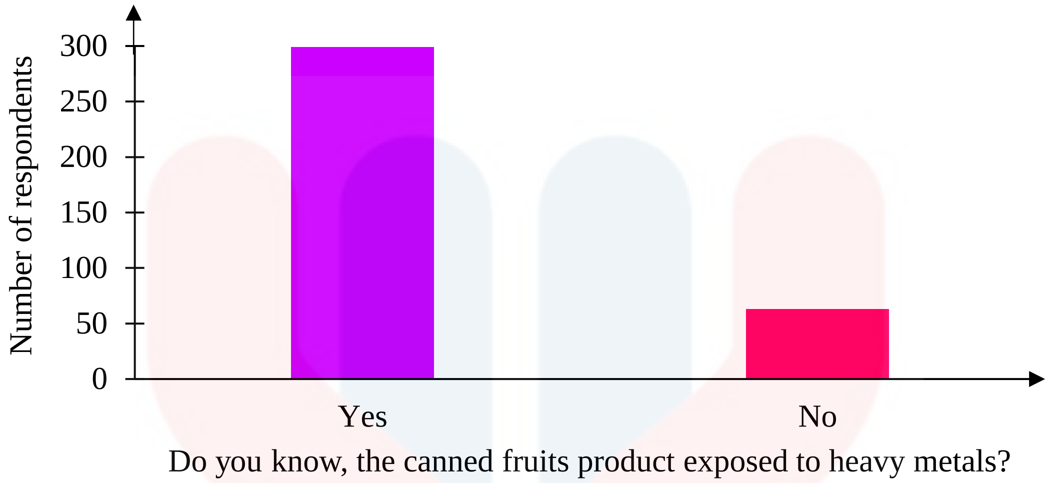

Figure 4.16: Respondents' knowledge towards heavy metal

in canned fruits product

4.7.2.6 Knowledge about Harm of Heavy Metal Towards Respondent's Body

The last question in the general knowledge of respondents towards the heavy metal is shown in Figure 4.17. The question is asked either the respondents know the excessive heavy metal residue in canned fruits product can harm the body in long term. Most respondents which are 315 out of 362 respondents answered yes to this question. That total leads to 87% which shows a high percentage while the other 47 respondents contribute 13% answered no. This result shows a positive sign because the total respondents know the long term of excessive heavy metals can harm the body so, the respondents can be careful in eating canned fruits product.

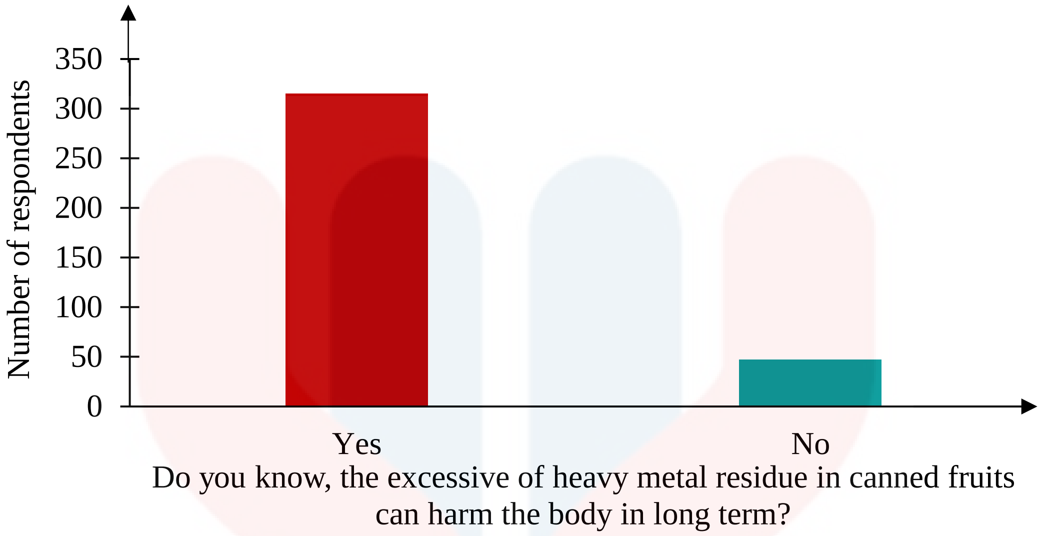

Figure 4.17: Respondents' knowledge towards heavy metal harming in body

4.7.3 Frequency of Canned Fruits Product Consumption by Respondents

4.7.3.1 Frequency of Canned Fruits Product Consumption in a Week

In this part, the questions focused on the frequent consumption of canned fruits by respondents as shown in Figure 4.18. This part only has two questions which are frequency consumption in a week and a month. For frequency of canned fruits product consumption in a week, the respondents were given a choice of answers to choose based on the frequency of their intake. Most respondents answered none which refers to not intake any canned fruits product in a week. 238 respondents answered none consuming canned fruits product in a week contribute 65.7%. 120 respondents answered 1-2 times frequency for consuming canned fruits product in a week contribute 33.1%. Only four respondents answered 3-5 times in a week while there are no respondents who answered 6-7 times and more than 7 times in a week.

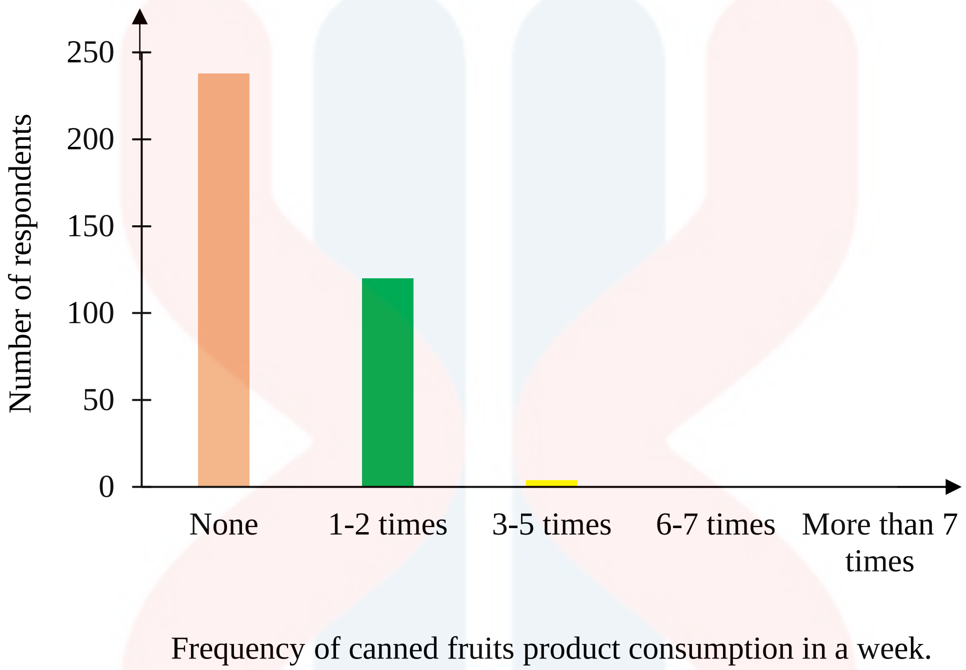

Figure 4.18: Frequency of canned fruits product onsumption

in a week by respondents

4.7.3.2 Frequency of Canned Fruits Product Consumption in a Month

This question about the frequency of canned fruits product consumption in a month by respondents is shown in Figure 4.19. As many as seven answer choices can be chosen by the respondents for this frequency that are none, 1-5 times, 6-10 times, 11-15 times, 16-20 times, 21-25 times, and more than 25 times. 181 respondents contributed 50.1% answered none which means these respondents did not consume any canned fruits product in a month. 171 respondents answered 1-5 times and 7 respondents answered 6-10 times frequency in consumed canned fruits product in a month. For 11-

15 times, only 2 respondents chose this answer. There are no respondents who answered 16-20 times, 21-25 times, and more than 25 times. Most respondents answered none because canned fruits product is not Malaysia's staple food, so the respondents did not always eat that except as dessert.

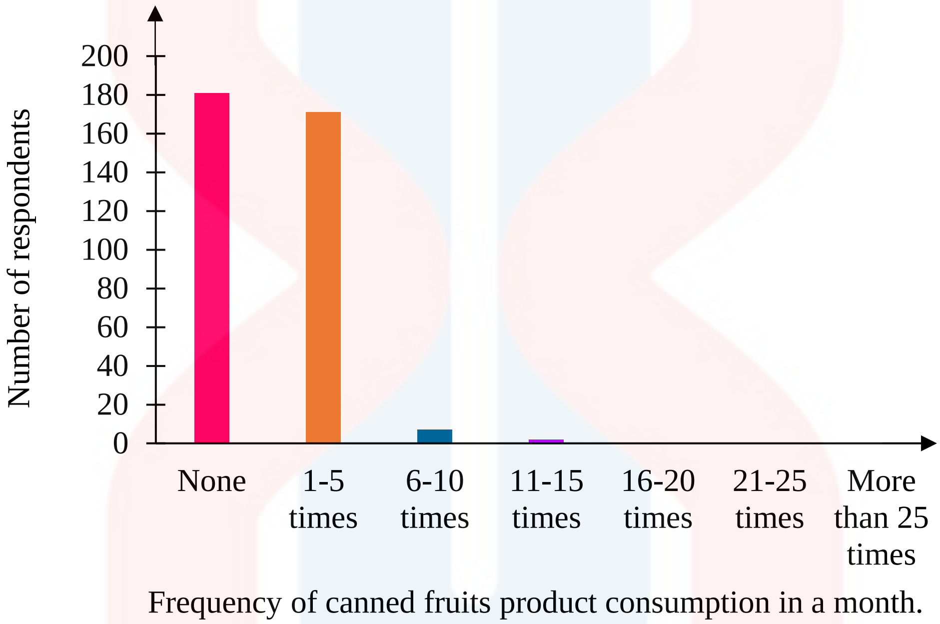

Figure 4.19: Frequency of canned fruits product onsumption

in a month by respondents

4.8 Health Risk Assessment

4.8.1 Estimated Daily Intake (EDI) of Adults in Canned Fruits Products

Figure 4.20 showed the estimated daily intake of adults in consuming canned fruits products. The highest intake was in Zn from lychee canned fruits which are 0.00167 mg/kg/day followed by cocktail canned fruits which are 0.00123 mg/kg/day. Pineapple canned fruits products were the next with the estimated daily intake was

0.00089 mg/kg/day and lastly was longan canned fruits 0.00086 mg/kg/day which just has slightly different daily intake with pineapple canned fruits. Zinc is required for the creation of proteins and nucleic acids, as well as regular body growth so it is essential when the concentration of Zn was high among the other metals due to it being important in the body (Ramaiya, Bujang & Zakaria, 2018).

The second highest was the concentration of Pb. The canned fruits of cocktail and pineapple had the same value of estimated daily intake which is 0.00067 mg/kg/day. Lychee canned fruits with 0.00054 mg/kg/day in Pb estimated daily intake and lastly was longan canned fruits which are 0.00051 mg/kg/day. Next, Cr is the third highest which is in cocktail canned fruit, estimated daily intake is 0.00016 mg/kg/day followed by pineapple canned fruits which are 0.00013 mg/kg/day, and longan canned fruits which is 0.00012 mg/kg/day. Lychee canned fruits became the lowest which is 0.00011 mg/kg/day in Cr estimated daily intake.

The estimated daily intake (EDI) in Cd resulted in the same value of EDI which is 0.00004 mg/kg/day in both cocktail canned fruits and pineapple canned fruits. Longan and lychee canned fruits also resulted in the same value of EDI in Cd which is 0.00006 mg/kg/day. In the concentration of Ni, the EDI was high in pineapple canned fruits which are 0.00015 mg/kg/day, followed by lychee canned fruits which are 0.00005 mg/kg/day, and cocktail canned fruits which is 0.00004 mg/kg/day. However, for longan canned fruits, the result was not detected due to the undetected concentration of heavy metal during analysis with AAS. In Institute for Public Health (IPH) (2014) reported the estimated daily intake of adults in canned fruits products in Malaysia was 0.29 g/day. This is considered as still low intake if compared with fresh fruits and dry fruits.

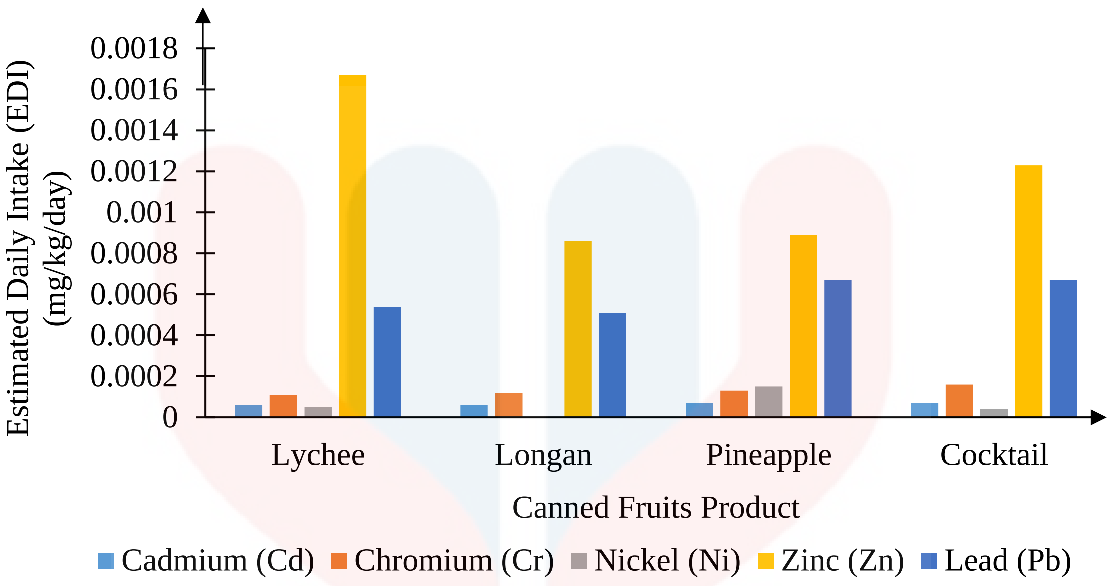

Figure 4.20: Estimated Daily Intake (EDI) (mg/kg/day)

4.8.2 Estimated Weekly Intake (EWI) of Adults in Canned Fruits Products

The rank of the highest estimated weekly intake (EWI) started with zinc (Zn), lead (Pb), chromium (Cr), cadmium (Cd) and nickel (Ni) was the lowest as shown in Figure 4.21. The highest Zn was in lychee canned fruits which are 0.00334 mg/kg/week followed by cocktail canned fruits which are 0.00246 mg/kg/week. Pineapple canned fruits were the third highest in which is 0.00178 mg/kg/week and lastly was longan canned fruits which is 0.00172 mg/kg/week. The highest EWI for Pb was cocktail canned fruits and pineapple canned fruits which are 0.00134 mg/kg/week for each. Longan canned fruits and lychee canned fruits both have the same EWI of 0.00102.

Next, the highest EWI for Cr was cocktail canned fruits (0.00032 mg/kg/week) trailed by pineapple canned fruits (0.00026 mg/kg/week). Lychee canned fruits had the lowest Cr content at 0.00022 mg/kg/week, after longan canned fruits at 0.00024 mg/kg/week. Cadmium (Cd) in pineapple canned fruits and cocktail canned fruits resulted in the same EWI which is 0.00014 mg/kg/week for both then, lychee canned fruits and longan canned fruits also had EWI which are 0.00012 mg/kg/week for both. Nickel, Ni, has the lowest metal of EWI for adults in canned fruits products. The highest EWI in Ni was pineapple canned fruits which are 0.0003 mg/kg/week then lychee canned fruits which are 0.0001 mg/kg/week and cocktail canned fruits which are 0.00008 mg/kg/week. Longan canned fruits did not have an estimated daily intake due to not detecting the result of Ni for longan canned fruits.

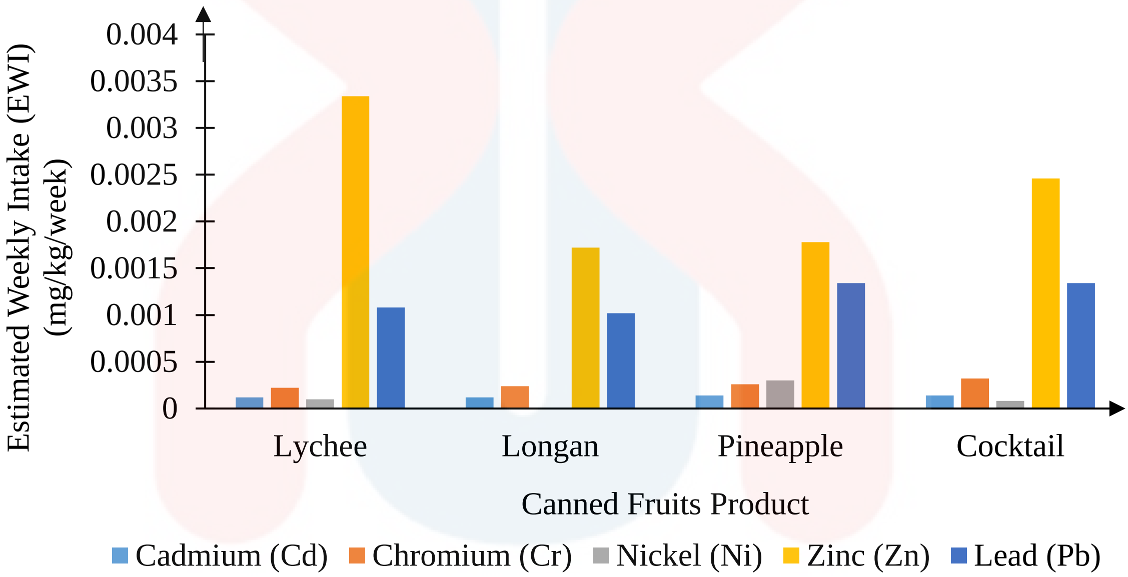

Figure 4.21: Estimated Weekly Intake (EWI) (mg/kg/week)

The comparison of the Estimated Daily Intake (EDI) and Estimated Weekly Intake (EWI) for adults in canned fruits products in this study showed as in Table 4.7. The EDI value was resulted in much smaller than EWI because of the calculation for the duration between both EDI and EWI. In EDI, the calculation time was around a day to know the essential intake in a day for adults in canned fruits products while for EWI the calculation time was around a week to know the essential intake in a week for adults in canned fruits products (Liao, Liu & Kannan, 2013). According to WHO/FAO (2011), the Tolerable Daily Intake (TDI) in canned fruits products for Cd which is 0.08

mg/kg/day, Cr is 0.03 mg/kg/day, Ni is 0.5 mg/kg/day, Zn is 3 mg/kg/day and Pb is 0.15 mg/kg/day.

The Provisional Tolerable Weekly Intake (PTWI) for adults in canned fruits products is 7 mg/kg/week in Cd, 23.3 mg/kg/week in Cr, 7 mg/kg/week in Ni, 35 mg/kg/per for Zn and 8 mg/kg/week for Pb. After the comparison made between EDI and EWI, the canned fruits products did not exceed the TDI and PTWI limit set by WHO/FAO (2011). Therefore, the canned fruits products in this study can declare as safe to eat.

Table 4.7: Comparison of Estimated Daily Intake (EDI) and Estimated Weekly Intake (EWI) for adults

Type of canned fruits products	**EDI (mg/kg/day)**					**EWI (mg/kg/week)**				
	Cd	**Cr**	**Ni**	**Zn**	**Pb**	**Cd**	**Cr**	**Ni**	**Zn**	**Pb**
Lychee	0.00006	0.00011	0.00005	0.00167	0.00054	0.00012	0.00022	0.0001	0.00334	0.00108
Longan	0.00006	0.00012	n.d*	0.00086	0.00051	0.00012	0.00024	0.0001	0.00172	0.00102
Pineapple	0.00007	0.00013	0.00015	0.00089	0.00067	0.00014	0.00026	0.0003	0.00178	0.00134
Cocktail	0.00007	0.00016	0.00004	0.00123	0.00067	0.00014	0.00032	0.00008	0.00246	0.00134
TDI (mg/kg/day)	0.8	0.03	0.5	3.0	0.15	-	-	-	-	-
PTWI (mg/kg/week)	-	-	-	-	-	7.0	23.3	7.0	35.0	8.0

n.d*: not detected

4.8.3 Target Hazard Quotient (THQ) and Hazard Index (HI) for Adults in Canned Fruits Products

The result of Target Hazard Quotient (THQ) and Hazard Index (HI) reported in Table 4.8 for the canned fruits products. The Target Hazard Quotient (THQ) for adults in canned fruits products involved all canned fruits products that were studied in this research which are lychee canned fruits, longan canned fruits, pineapple canned fruits, and cocktail canned fruits. The THQ in Cd for lychee canned fruits has a value of 6.94 x 10^{-5}, THQ in Cr has a value of 1.11 x 10^{-3}, and THQ in Ni has the value of 2.31 x 10^{-7}. Zn THQ value is 5.55 x 10^{-6} and THQ for Pb is 1.26 x 10^{-3}.

The THQ value in longan canned fruits for Cd is 5.55 x 10^{-5}, Cr is 1.24 x 10^{-3}, Zn is 2.84 x 10^{-3} and Pb is 1.18 x 10^{-3}. Next, for the pineapple canned fruits, THQ for Cd is 6.90 x 10^{-5}, THQ for Cr is 1.33 x 10^{-3}, THQ for Ni is 7.37 x 10^{-6}, THQ for Zn is 2.96 x 10^{-6}, and Pb 1.54 x 10^{-3}. Lastly, cocktail canned fruits have THQ for Cd is 6.90 x 10^{-5}, THQ for Cr is 1.61 x 10^{-3}, THQ for Ni is 1.84 x 10^{-6}, THQ for Zn is 4.07 x 10^{-6}, and Pb 1.54 x 10^{-3}.

Thus, the average value of THQ Cd is 2.69 x 10^{-4}, Cr is 5.29 x 10^{-3}, Ni is 9.44 x 10^{-6}, Zn is 1.54 x 10^{-5} and Pb is 5.52 x 10^{-3}. In the result of the Hazard Index (HI) for adults on canned fruits products, all the metals from THQ which are Cd, Cr, Ni, Zn, and Pb was added to get HI value. From the calculation, the result of HI for canned fruits products in this research is 0.01 which means less than 1. Therefore, the canned fruits products that are sold in Malaysia can be categoried as safe to consume for humans and not thought to pose a carcinogenic risk (Fakhri et al., 2019).

Table 4.8: Target Hazard Quotient (THQ) and Hazard Index (HI) for adults in canned fruits products

Type of canned fruits products	Target Hazard Quotient (THQ)					Hazard Index (HI)
	Cd	Cr	Ni	Zn	Pb	
Lychee	6.94×10^{-5}	1.11×10^{-3}	2.31×10^{-7}	5.55×10^{-6}	1.26×10^{-3}	2.45×10^{-3}
Longan	5.55×10^{-5}	1.24×10^{-3}	n.d*	2.84×10^{-6}	1.18×10^{-3}	2.48×10^{-3}
Pineapple	6.90×10^{-5}	1.33×10^{-3}	7.37×10^{-6}	2.96×10^{-6}	1.54×10^{-3}	2.95×10^{-3}
Cocktail	6.90×10^{-5}	1.61×10^{-3}	1.84×10^{-6}	4.07×10^{-6}	1.54×10^{-3}	3.22×10^{-3}
Average Value	2.69×10^{-4}	5.29×10^{-3}	9.44×10^{-6}	1.54×10^{-5}	5.52×10^{-3}	0.01

n.d*: not detected

CHAPTER 5

CONCLUSION AND FUTURE RECOMMENDATIONS

5.1 Conclusion

The canned fruits product is the one of fruits preservation to maintain the quality for a long period and it is the fruits and sugar concoction. It was a great preservation method, but the packaging materials manufactured by heavy metals such as aluminum and tin can contaminate the fruits. The fruits are also already contaminated with heavy metal during in crops land which is from soil and fertilizing process. The agricultural and industrial waste contains heavy metals and chemicals that spread from the rain and water flow absorb into the soil, then the plant uptake that water. The heavy metal content in the fruit increases due to the waste that occurs during the water flow process. Therefore, it is necessary to ensure the canned fruits products are safe because the human will eat it and it will enter the body with that heavy metal contamination.

In this study, four canned fruits products which are longan canned fruits, lychee canned fruits, pineapple canned fruits, and cocktail canned fruits were used as the samples to analyse the heavy metal concentration level. Those canned fruits were purchased from the local market store at Kelantan and the average of heavy metals concentration were arranged by descending order which is Zn > Pb > Cr > Cd > Ni. From three types of canned fruits which are longan canned fruits, pineapple canned fruits, and cocktail canned fruits showed Zn was the highest in that three types of canned fruits followed by lead which is high in lychee canned fruits. Chromium was in the third rank, next was cadmium, and nickel was the last for the average heavy metal concentration. The results of the average canned fruits products were Zn (0.251 mg/kg), Pb (0.123 mg/kg), Cr (0.029 mg/kg), Cd (0.012 mg/kg) and Ni (0.01 mg/kg). As a result, all the heavy metal concentrations in canned fruits products were not exceed the permissible limit set by WHO/FAO (2011) and MFA (1985).

In the health risk assessments, Estimated Daily Intake (EDI) for all canned fruits products resulted as not exceed than the Tolerable Daily Intake (TDI) marked by WHO/FAO. The Estimated Weekly Intake (EWI) for all canned fruits products also resulted as below the limit by Provisional Tolerable Weekly Intake (PTWI) set by WHO/FAO. Therefore, people can eat canned fruits products because there was no danger to their health. The Hazard Index (HI) in this study was 0.01 which is less than 1 so there were no evident dangers when eating canned fruits products.

5.2 Future Recommendations

The packaging of canned fruits product becomes the highest risk of contaminating the heavy metal into the fruits if, during the canning method, the process did not conduct strictly. In coating the can avoid using major metal components such as aluminum and copper because it has a detrimental effect on corrosion resistance. It is possible to form a tinplate with good corrosion and processing resistance when that metal avoids using in coating the can. The industry can expand the manufacture of cans by using the chrome-plated sheet to replace the usage of other major metals. This technique is great in reducing the migration of harmful paint coating for printing enters the food.

Lastly, the adverse effects of heavy metals on health should be disseminated to the public so that they are more careful and do not consume heavy metals beyond the limit. This knowledge is important in ensuring all Malaysian are free from heavy metal contamination-related diseases such as cancer. If in the past the information was quite limited to be accessed by the public to gain awareness of the dangers of heavy metal. Nowadays, it cannot be the reason because any information is just at the fingertips. This knowledge can spread using social media, any articles online, and many other methods. Thus, knowing the recommended daily intake in consuming the canned fruits products is crucial in ensuring that the health is always good.

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APPENDIX A

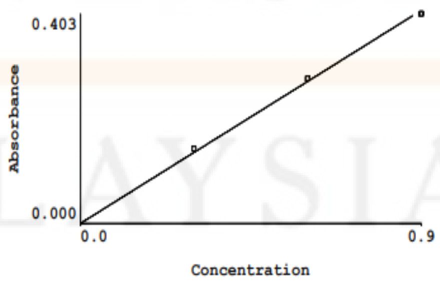
Blank calibration measurement for each heavy metals

Heavy metal	Average concentration (mg/kg)	Standard deviation
Cd	0.00	0.00
Cr	0.00	0.00
Ni	0.00	0.00
Zn	0.00	0.00
Pb	0.00	0.00

APPENDIX B

Standard calibration curve for each heavy metal using AAS.

i) Cadmium (Cd)

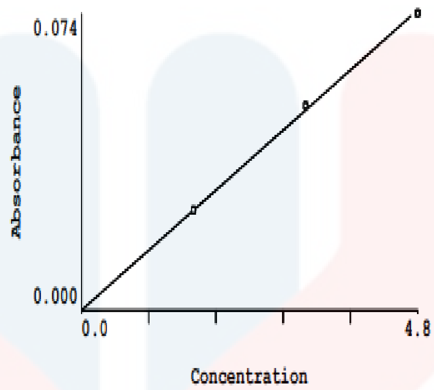


Calibration data for Cd 228.80 Equation: Linear Through Zero

ID	Mean Signal (Abs)	Entered Conc. mg/L	Calculated Conc. mg/L	Standard Deviation	%RSD
Calib Blank 1	0.0000	0	0.000	0.00	>999.9%
Calib Std 1	0.1436	0.3	0.315	0.00	0.56
Calib Std 2	0.2787	0.6	0.612	0.00	0.22
Calib Std 3	0.4034	0.9	0.886	0.00	0.44

Correlation Coef.: 0.998379 Slope: 0.45523 Intercept: 0.00000

ii) Chromium (Cr)

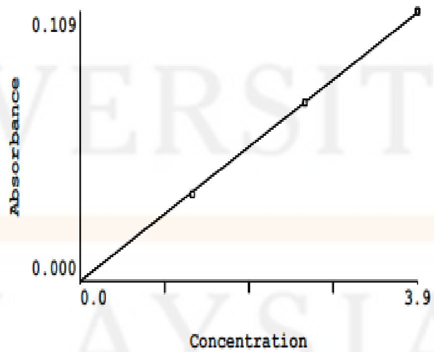


Calibration data for Cr 357.87 Equation: Linear Through Zero

ID	Mean Signal (Abs)	Entered Conc. mg/L	Calculated Conc. mg/L	Standard Deviation	%RSD
Calib Blank 1	0.0000	0	0.000	0.00	>999.9%
Calib Std 1	0.0249	1.6	1.603	0.00	0.80
Calib Std 2	0.0508	3.2	3.272	0.00	0.22
Calib Std 3	0.0737	4.8	4.749	0.00	0.79

Correlation Coef.: 0.999236 Slope: 0.01552 Intercept: 0.00000

iii) Nickel (Ni)

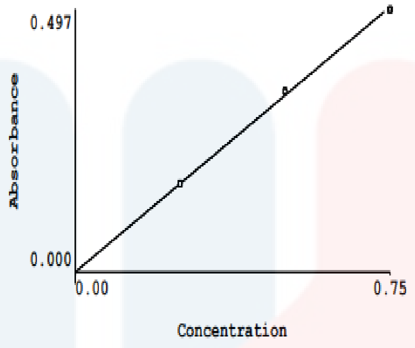


Calibration data for Ni 341.48 Equation: Linear Through Zero

ID	Mean Signal (Abs)	Entered Conc. mg/L	Calculated Conc. mg/L	Standard Deviation	%RSD
Calib Blank 1	0.0000	0	0.000	0.00	>999.9%
Calib Std 1	0.0350	1.3	1.260	0.00	0.81
Calib Std 2	0.0720	2.6	2.594	0.00	0.28
Calib Std 3	0.1087	3.9	3.917	0.00	0.91

Correlation Coef.: 0.999710 Slope: 0.02776 Intercept: 0.00000

iv) Zinc (Zn)

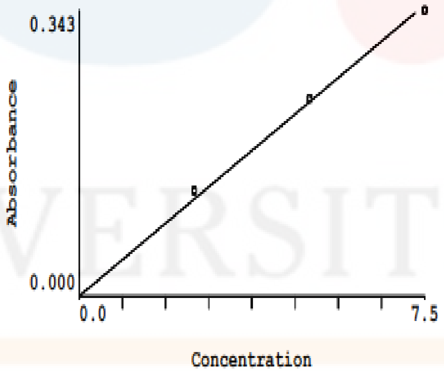


Calibration data for Zn 213.86 — Equation: Linear Through Zero

ID	Mean Signal (Abs)	Entered Conc. mg/L	Calculated Conc. mg/L	Standard Deviation	%RSD
Calib Blank 1	0.0000	0	0.000	0.00	>999.9%
Calib Std 1	0.1671	0.25	0.250	0.00	0.90
Calib Std 2	0.3424	0.50	0.511	0.00	0.34
Calib Std 3	0.4970	0.75	0.742	0.00	0.61

Correlation Coef.: 0.999243 Slope: 0.66954 Intercept: 0.00000

v) Lead (Pb)



Calibration data for Pb 217.00 — Equation: Linear Through Zero

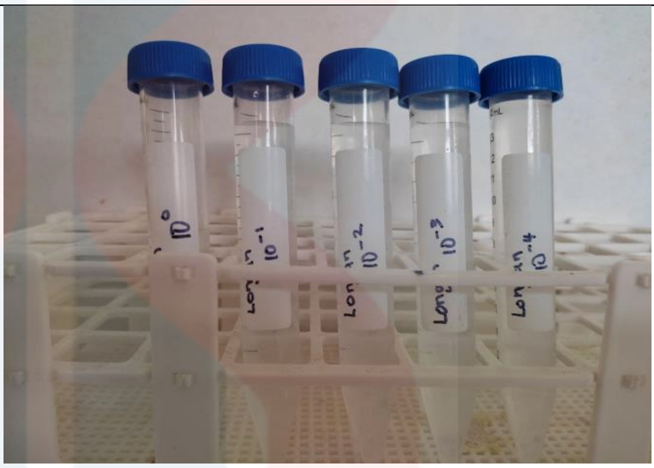
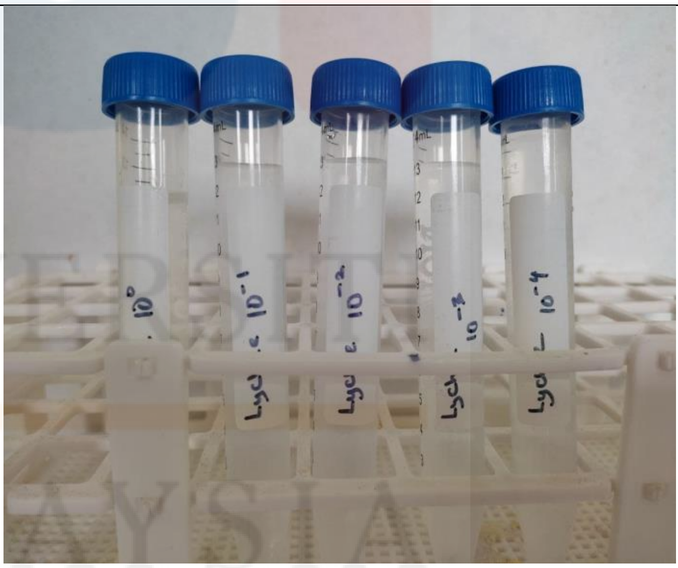
ID	Mean Signal (Abs)	Entered Conc. mg/L	Calculated Conc. mg/L	Standard Deviation	%RSD
Calib Blank	0.0000	0	0.000	0.00	>999.9%
Calib Std 1	0.1264	2.5	2.711	0.00	0.12
Calib Std 2	0.2370	5.0	5.081	0.00	0.34
Calib Std 3	0.3435	7.5	7.366	0.00	0.37

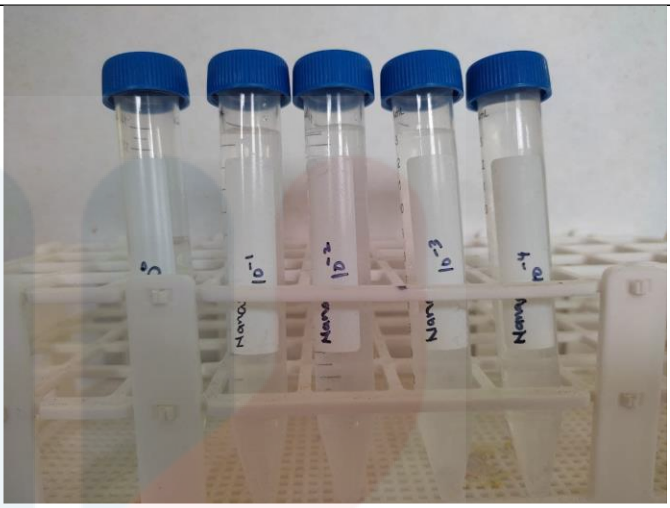
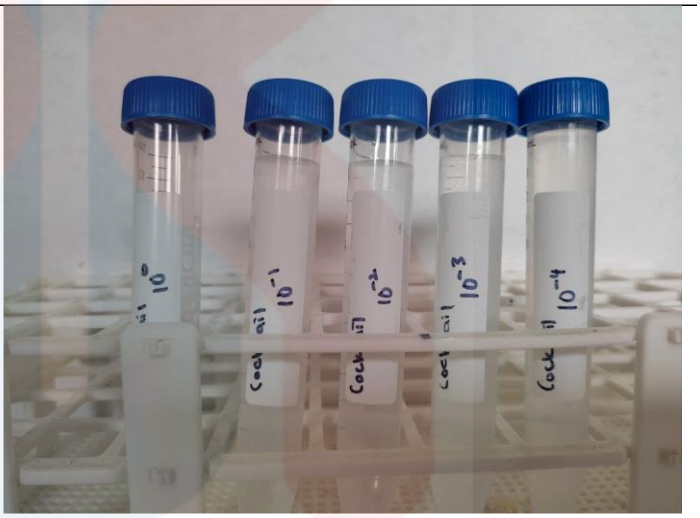
Correlation Coef.: 0.997233 Slope: 0.04663 Intercept: 0.00000

APPENDIX C

15 mL of sample solution and serial dilution samples of

10^{o}, 10^{-1}, 10^{-2}, 10^{-3}, and 10^{-4} from left to the right

Types of canned fruit	Sample solution and serial dilution
Longan	
Lychee	

Pineapple	
Cocktail	

APPENDIX D

TURNITIN SIMILARITY REPORT

Heavy Metal Determination and Health Risks Assessments of Selected Canned Fruits Product

ORIGINALITY REPORT

10%	7%	7%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universiti Malaysia Kelantan Student Paper	3%
2	www.ncbi.nlm.nih.gov Internet Source	<1%
3	Submitted to Higher Education Commission Pakistan Student Paper	<1%
4	umpir.ump.edu.my Internet Source	<1%
5	worldwidescience.org Internet Source	<1%