Detection of Heavy Metals in Palm Oil at Different Stages of Processing

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ABSTRACT

Edible oils, in this case palm oil, were extracted and processed world-wide and important as domestic and international commodities. The determination of heavy metals in palm oil has gained more importance nowadays because they contain natural antioxidants and essential elements and also these oils were used in many aspects of food production, such as baking and frying and for the manufacturing of margarine, snack foods and other oil products. Samples collected from different stages of milling process were analyzed using Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP-OES) to determine the presence and types of heavy metals found in the oil. Determination of heavy metals in palm oil samples using ICP-OES has been proved to be reliable, fast and precise method. The amounts of heavy metals detected were under maximum level of CODEX Standard but still can be improved so that the quality of our palm oil products can be further improved.

Keywords: *palm oil, heavy metals, ICP-OES*

Introduction

Growing global demand for edible oils and animal proteins in the last decade or two had resulted in a tremendous increased in the areas under oil crops cultivation, particularly of soybean and oil palm. The Malaysian oil palm industry recorded an impressive performance in 2010. As noted in Malaysian Palm Oil Board report (MPOB, 2011), the total oil palm planted area in 2011 reached 5.00 million hectares, an increase of 3.0% against 4.85 million hectares recorded the previous year.

Palm oil is a form of edible vegetable oil, not an animal or diary product therefore is cholesterol-free. Food manufacturers choose palm oil because it has a distinct quality, requires little or no hydrogenation and prolongs the shelf life of products. American Palm Oil Council (APOC, 2004) stated that these advantages are difficult to duplicate at the same cost with polyunsaturated oils, which often command higher market prices and require additional processing for the same characteristics.

The quality of food products has received great attention due to its influence on human nutrition and health. The concentration of heavy metal in edible oils is an important criterion for the assessment of their quality in regard to freshness, keeping properties and storage. Heavy metals are particularly worrisome contaminants in foods and the environment. In general, they are not biodegradable and they have long biological half-lives. Heavy metals have potential for accumulation in humans from various plants and other natural sources, posing serious health hazards for conditions such as renal failure, symptoms of chronic toxicity and liver damage.

For many contaminants, health authorities recommend maximum acceptable levels that are considered to be safe in food such as palm oil. It is illegal for foods containing higher levels to be sold although the occasional consumption of slightly higher amounts is unlikely to be harmful. The level of contaminants in our food must comply with the limits recommended by health authorities. However, because the uncertainty in establishing exactly what is safe level for many of these contaminants especially in the case of heavy metal in palm oil of large corporation in Malaysia is very important because these large corporation supply their products not only for local market but also for international market.

The content of heavy metal in edible oils depends on several factors. The metals can be incorporated into the oil from the soil or be introduced during the production process. The presence of heavy metals is known to have different effects on the oxidative stability of edible oils. Lead is potentially present in oils caused by environmental contamination. As noted by Ardelt, *et. al.*, (2006) vegetables oils naturally contain high amounts of phospholipids, calcium and magnesium and also trace levels of iron and copper. Higher concentrations of

these elements can affect the oil products' quality because they influence the products' flavour, colour and also the shelf life of the oil. It is also same with nickel, which is used as a catalyst during the production process and needs to be removed to avoid oxidation of the product. Contamination levels of lead and arsenic need to be controlled in the last stage of processing the product.

Zeiner, *et. al.*, (2005) have stated that the analysis of vegetable oils is dominated by the determination of classic parameters such as acidity, peroxide value, ultraviolet absorption and the fatty acid composition. The analytical criteria are the basis for international regulations on the definition of oil genuineness and quality. Recently proposed methods for oil analysis are the determination of flavouring components of edible oils by chromatographic techniques and isotopic assays and assessment of sterols and triglycerols in edible oil. In addition to the determination of organic oil parameters, the trace elemental analysis plays an important role and as basis for oil characterization, oil adulteration detection and because of the metabolic role of some metals. Accurate elemental analysis of edible oils requires analytical methodology that is both sensitive and selective.

There are few studies of heavy metals detection in edible oils such as Determination of Trace Elements in Edible Oils by Leeman Labs. Inc. (2006), Trace Elemental Characterization of Edible Oils by ICP-AES and GFAAS by Cindric, Zeiner and Steffan (2006), Estimation of Residual Nickel and Some Heavy Metals in Vanaspati Ghee by Hizbullah Khan, *et.al.* (2007) and Determination of Some Inorganic Metals in Edible Vegetable Oils by ICP-AES by Erol Pehlivan, *et. al.*, (2008).

Due to its multi-element determination capability, high dynamic linear range and sensitivity, Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) is widely used in the analysis of oils and fats. Leeman Labs. Inc. (2006) proved that ICP-OES meets these requirements and has the capability of determining up to 70 different elements in a sample. ICP-OES permits close monitoring of elemental content throughout processing; starting with the raw oil and continuing through to the finished products. Trace metal analysis is an important part of quality control as well as final quality check.

This study is designed to determine the presence of selected heavy metals that can be found in palm oil at different stages of processing, quantify the amount of selected heavy metals in the oil and also give recommendations for managing the safety of palm oil. It is important to determine the presence of heavy metals in palm oil in order to maintain the quality of our palm products so that people will trust in our palm products and this will increase our export of palm oil and also indirectly increase the Malaysian economy. The recommendations given can help in enhancing our quality of palm products to be in line with the international standard request so that other countries will never have any excuses in denying our products.

Materials and Methods

Sample Collection and Preparation

500 ml of palm oil were collected at five different stages of refinery processing; crude palm oil (CPO), bleached palm oil (BPO), RBD palm oil (RBDPO), free fatty acid (FFA) and RBD palm olein CP6 (Olein). Sample preparation follows the Standard Test Method for Determination of Additive Elements, Wear Metals and Contaminants in Used Oils and Determination of Selected Elements in Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES, 1997). A weight portion of oil was diluted ten-fold by weight with mixed kerosene. The standard was also prepared in the same manner.

Apparatus

This study was performed using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) for detection and quantification of heavy metals in palm oil sample.

Calibration

Calibration method followed the Standard Test Method for Determination of Additive Elements, Wear Metals and Contaminants in Used Oils and Determination of Selected Elements in Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES, 1997).

Results and Discussion

Five selected heavy metals were determined during analyzing the samples using ICP-OES. The selected heavy metals were copper (Cu), lead (Pb), arsenic (As), cadmium (Cd) and chromium (Cr) and they were selected to be determined because the high level of these elements would affect the safety and quality of the oil products and also affect human health if they were consumed regularly.

Result showed that all the selected heavy metals were found in the oil but in a small level and below the maximum level of CODEX Standard. The highest heavy metal found in the sample were copper (Cu) and arsenic (As), both below 0.05 mg/L in crude palm oil (CPO) and along the refinery process until RBD palm olein CP6 (Olein), which were below the acceptable level of CODEX Standard and if they were above the maximum level of CODEX Standard, it can be toxicity and can cause serious health problem to our body.

As noted in FAO Corporate Document Repository (2007), contamination from copper (Cu) and arsenic (As) in CPO could be from the digestion when the highest rate of metal wear was encountered in the milling process, from the pesticides, fungicides and the irrigation water. Heavy metals contamination increased the risk of oil oxidation and onset of oil rancidity.

Lead (Pb), cadmium (Cd) and chromium (Cr) were also found in a small amount of below 0.02 mg/L in all samples. Caring Medical and Rehabilitation Services Illinois (2008) stated that cadmium (Cd) can be incorporated in the oil from fungicides, fertilizer, soil and also irrigation water.

Those selected heavy metals were below the maximum level of the CODEX Standard but the refinery mill must always beware of their products that contained heavy metal even though it was in a small amount because as noted by Killic (2008), heavy metals have potential for accumulation in humans bodies and could caused serious health hazards for conditions such as renal failure, symptoms of chronic toxicity and liver damage because heavy metals cannot be degraded or destroyed and they have long biological half-lives. They will stay for a long time in human body and from time to time they will accumulate and increase to a large amount if our oils were not treated properly in the refining stage. The refinery mill can improve the oil quality by applying Hazard Analysis and Critical Control Points (HACCP) at certain points in the mill along the way of refinery processing and always monitor and review the results regularly so that they always comply with the CODEX and international standard to prevent risk for human health and also to increase their export products to overseas; so that people outside of our country will believe and want to buy our products.

Conclusion and Recommendations

ICP-OES was a simple, fast, accurate and precise method for the determination of heavy metals in edible oils and fats in this case, heavy metals in palm oil. For clear oil samples, after dilution with kerosene, direct aspiration technique should be applied because it can give good sensitivities, easy to apply, fast and also can produce accurate results.

In food business, the hazards can be controlled through the adoption of Good Manufacturing Practice (GMP). The purposes of GMP were to optimise the useful life of cooking oil, maintain food acceptability and wholesomeness, avoid extensive oxidative decomposition, avoid development of objectionable flavour and avoid formation of polymeric compounds. GMP includes the following points; choosing cooking oil of good quality and consistent stability, using properly designed equipment, selecting the lowest possible frying temperature, filtering cooking oil frequently to remove food particles, shutting down and cleansing equipment frequently, replacing cooking oil as needed to maintain high quality, providing adequate training to personnel, testing cooking oil frequently throughout the frying process.

Malaysian government must also impose certain rules and regulations to food industry so that people involved will always comply with the rules and regulations. In addition, regular inspection must be carried out by the officers from the Ministry of Health Malaysia to the company related with food industry. This can enhance the safety of the foods that are sold to the end consumer.

Moreover, through its foods surveillance programme, the Ministry of Health Malaysia must monitor the quality of cooking oil. Inspectors will take samples of cooking oil for analysis to ensure that they are suitable for cooking and safe for human consumption. Law on food safety must state that sale of food which is not fit for human consumption is an offense. Offenders shall be liable to a fine of RM50,000 and imprisonment of 6 months. This can scare the related company so that they will comply with the standard food safety management.

Top managements of the company related also must train their employees on how to manage the safety of their products. The factory must be clean from anything that are not necessary in the area especially rubbish and dirt.

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