HEALTH RISK ASSESSMENT OF HEAVY METALS IN COMMONLY CONSUMED COOKING OILS IN IBADAN METROPOLIS

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ABSTRACT

Cooking oils belong to a large group of substances consumed on a daily basis. Consumption of heavy metals introduced during processing may pose a threat to human health. 200 Questionnaires were administered to know the commonly consumed cooking oils and assess the awareness of health implication of its consumption. Levels of Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Copper (Cu) in four varieties of edible cooking oils (Vegetable, Palm, Coconut and Soy oils) collected in Apata and Bodija markets in Ibadan were digested and heavy metal levels were determined using Atomic Absorption Spectrophotometer (AAS). The results were compared with WHO/FAO standards. A Health Risk Assessment study was carried out using WHO mathematical model. 40% of the respondents consumed KG oil, 62.4% were aware of the adverse effects of cooking oil while 98% opined that there are health benefits in consumption of cooking oils. The concentrations of Pb, Cd, Ni and Cu were observed in the range of 4.45-9.15, 0.03-1.5, 0.73-4.78, 5.25-7.5, 0.005-0.025 mg/kg respectively. Heavy metal levels in all cooking oils were higher than WHO/FAO limit except in Cu. The concentrations (mg/L) of Ni, Pb, Cr, Cu and Cd (5.250-10.000, 1.325-9.150, 0.725-4.775, 0.005-0.025 and 0.025-1.875 respectively) were observed to be higher than JECFA recommended limits except Cu. Estimated Dietary Intake (mg/kg/day) of Cd, Pb and Ni (0.246-0.402, 1.384-2.152 and 2.277-2.525 mg/kg/day respectively) were higher than the Oral Reference Dose (RfD) (mg/kg/day) values (0.001, 0.004 and 0.020 mg/kg/day respectively) while Cr, Mn and Cu 0.281-1.091, 0.023-1.859 and 0.002-0.015 mg/kg/day respectively and were within the RfD values (1.500, 11.000 and 2.500 mg/kg/day respectively). Health Risk Index (HRI) values were less than 1 indicating that consumption of the cooking oils, if consumed, does not pose toxicological risk to human health, however continuous intake may put consumer's health at risk.

KEYWORDS: Atomic Absorption Spectrometry, Cooking oils, Health Risk Assessment, Estimated Dietary Intake.

INTRODUCTION

The determination of trace metal content in cooking oils is an important criterion for assessment of oil quality with regard to freshness, storage. Heavy metals accumulate in tissues of the liver and the brain thereby causing nervous disorders.[1]. They can also cause pathological and carcinogenic effects[2]. Many reports have described the deleterious effects that trace metals have on flavor and oxidationof fatty acid chains, exerting a deleterious influence on shelf-life and nutritional value[3].

It is possible to find the presence of metals due to treatment processes and steps like bleaching, hardening, refining and deodorization, corrosion of processing equipment, packaging, presence of pesticide residue used in agriculture, industries close to the site of cultivation.[4]. Metals and their compounds can accumulate in the body's tissues, such as bones or nerves. Children are the most susceptible to health problems caused by heavy metals, because their bodies are smaller and still developing.[5] The health hazards presented by heavy metals depend on the level and the length of exposure.[6] The present work deals with the quantification of heavy metals (lead, cadmium, chromium, Nickel and copper) concentrations in commonly consumed cooking oil in Ibadan Metropolis. The data enable us to estimate heavy metal intakes in adults and to compare them with Acceptable Daily Intakes (ADIs) of the Food and Agricultural Organization/ World Health Organization (FAO/WHO), so as to assess potential health hazards.

MATERIALS AND METHODS

QUESTIONNAIRE ADMINISTRATION:

200 Questionnaires were randomly administered to some areas in Ibadan, to know the most commonly consumed of cooking oils products such as different palm oil, different vegetable oil (branded and unbranded) and coconut oil in order to evaluate people's knowledge on the health benefits and risks of consumption.

Sample collection

The cooking oils were purchased from Apata and Bodija market in Ibadan, Nigeria.

Digestion of oil samples

Conical flasks and sample bottles were cleaned thoroughly with detergent and tap water, rinsed with distilled water, soaked in dilute nitric acid then rinsed thoroughly with deionized distilled water. The standard solutions for each element used for calibration were freshly prepared by diluting stock standard solutions for each element (1000 mg/L) in nitric acid solution immediately before use. The calibration ranges were selected according to the concentrations of the elements of interest and depending on the technique applied. 1g of each oil sample was digested with 10 mL of concentrated HNO3 with heating on the hot plate at 100oC for 15 minutes in a fume cupboard. All sample solutions were clear. The digest was then allowed to cool and was filtered using ashless Whatman filter paper and made up to 25 mL with distilled water.[7]

STATISTICAL ANALYSIS

Descriptive statistics was used for the data collected from questionnaire administration while data for the heavy metal concentration determination were subjected to 2-way Analysis of Variance (ANOVA).

Health Risk Assessment

Health risk assessment was done to provide individuals with an evaluation of their health risks and quality of life. The potential health risk of heavy metal consumption through cooking oils were assessed based on the daily intake of metals (DIM) and Health Risk Index (HRI).[8,9]

Daily Intake of Metals (DIM)

The daily intake of metals was calculated to estimate the heavy metal loading into the body system of a specified body weight of a consumer. This will inform the relative phyto-availability of metals and can easily tell the possible ingestion rate of a particular metal. The estimated daily intake in this study was calculated based on equation 1.0 below:

$$\mathrm{DIM} = \frac{\mathrm{C_{metal}} \times \mathrm{D_{food\ intake}}}{\mathrm{B_{average\ weight}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ 1.0$$

Where Cmetal is the heavy metal concentration in cooking oil samples

Dfood intake is the daily intake of cooking oils.

The daily intake of cooking oil is 1 g/day while the average body weight used was 70 kg for this study.[10]

Health risk index

The health risk index was calculated to know the ratio of the daily intake of metals to the oral reference dose. It was estimated using the equation below:

$$\mathrm{HRI} = \frac{\mathrm{DIM}}{\mathrm{R_F\ D}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 2.0$$

RfD is the oral reference dose for the metal (mg/kg/day) (Pb, Cr, Cd, Cu and Ni values were 0.004, 1.500, 0.001, 2.500 and 0.020 mg/kg/day, respectively) the average weight of adults consumption of cooking oil per day is 70 kg. If the value of HRI is less than 1 then the exposed population is said to be safe.[11]

RESULTS AND DISCUSSION

Statistical Analysis of Questionnaire

The figures below show some of the information obtained from questionnaire administration. It was discovered that 100% of the respondents consumed cooking oil products, however 62.4% of the respondents had tertiary education, 27% were educated to secondary level, and 4.2% had just primary education while 6.3% of the respondents did not have any formal education.

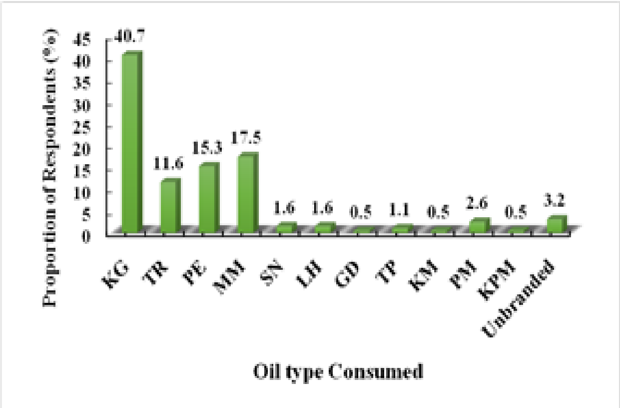

Figure 1: Proportion of Study Participants vis-a vis Oil Type Consumed

The proportion of participants that consumed cooking oils is shown in Figure 1. However out of the respondents that consumed cooking oils, 40.7% consumed KG, 11.6% consumed TR, 15.3% consumed PE, 17.5% consumed MM, 1.6% consumed SN, 1.6% consumed LH, 0.5% consumed GD, 1.1% consumed TP, 0.5% consumed KM, 2.6% consumed PM, 0.5% consumed KPM and 3.2 consumed unbranded oil. It is evident that KG has the highest consumers while GD, KM and KPM had lowest consumer.

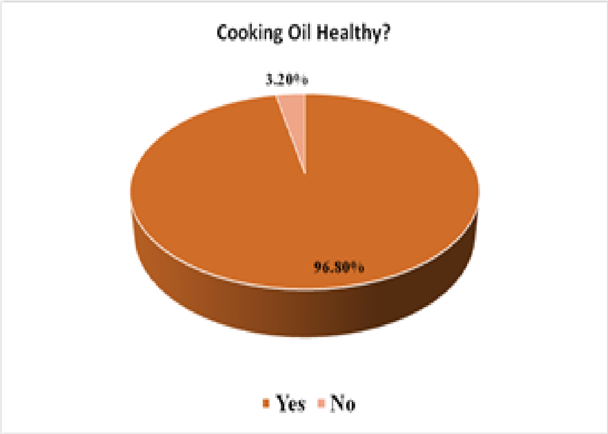

Figure 2: Health Awareness of cooking oil

Out of all the respondents, 96.80% were aware of cooking oil being healthy, 3.20% were not aware (figure 2). This shows that the percentage of those who were aware of health benefits of cooking oils were more than those that were not aware. Cooking oils have been found to have different nutritional components such as vitamin E (Tocopherol), omega-3 and omega-6 fatty acids, polyunsaturated, monounsaturated fat and saturated fats. Cooking oils like coconut oil contains lauric acid (monolaurin), which is known to reduce Candida, fight bacteria and create a hostile environment for viruses. Alpha-linolenic acid, a type of omega-3 fatty acids, are found in soybean, canola and flaxseed oil, they also have an anti-inflammatory properties which is why they are highly recommended for people suffering from chronic heart, skin and digestive concerns. Coconut and cooking oil also improves digestion as it helps the body absorb fat-soluble vitamins, calcium and magnesium and thus helps to treat or prevent stomach ulcers and ulcerative colitis. It can help improve bacteria and gut health by destroying bad bacteria.[12]

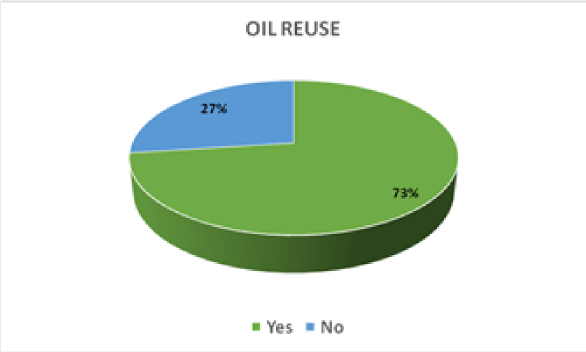

Figure 3: Rate of cooking oil reuse

It was observed that 73% of the respondents reused their cooking oil while 27% did not reuse their cooking oil. Hence large percentages of consumer reuse their cooking oils (figure 3).

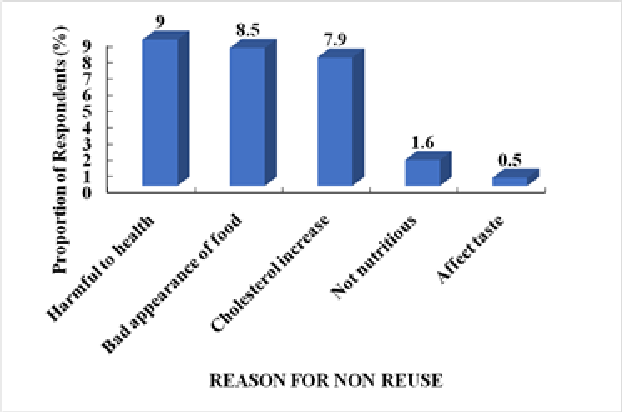

Figure 4: Reason for non reuse of cooking oil

From Figure 4, 9% agreed that reusing of cooking oil is harmful to humans health, 8.5% agreed that reusing causes bad appearance of food, 2.9% believed that reusing of cooking oils increases the cholesterol, 1.6% believed that reused oil is not nutritious to human body while 0.5% agreed that reusing of cooking oils affect the taste.

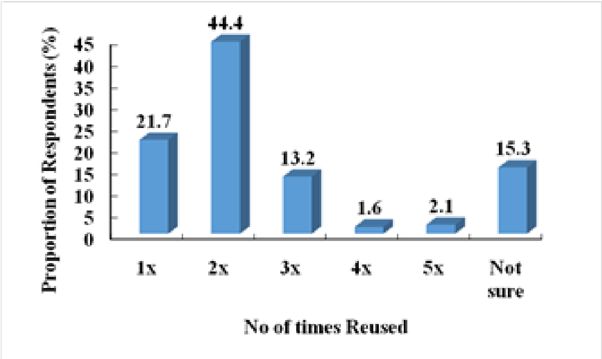

Figure 5: Number of times of cooking oils reuse

Out of all the respondents that consumed cooking oils, 21.7% reused cooking oil one time, 44.4% reused cooking oil two times, 13.2% reused cooking oil three times, 1.6% reused cooking oil four times, 2.1% reused cooking oil five times and 15.3% could not specify how often they reused the cooking oil (figure 5)

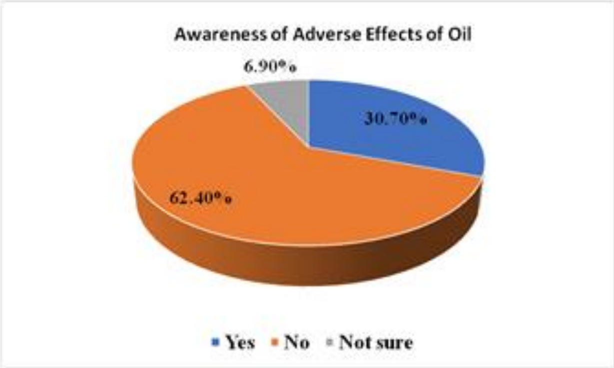

Figure 6: Awareness of adverse effects of cooking oil

It was observed that 62.40% of cooking oil consumers were aware of adverse effects of consuming it, 30.70% were not aware while the other 6.90% were not sure of hazard in cooking oil (figure 6), however with the figure above percentage of consumer awareness is greater than percentage of those that were not aware of hazard in cooking oil.

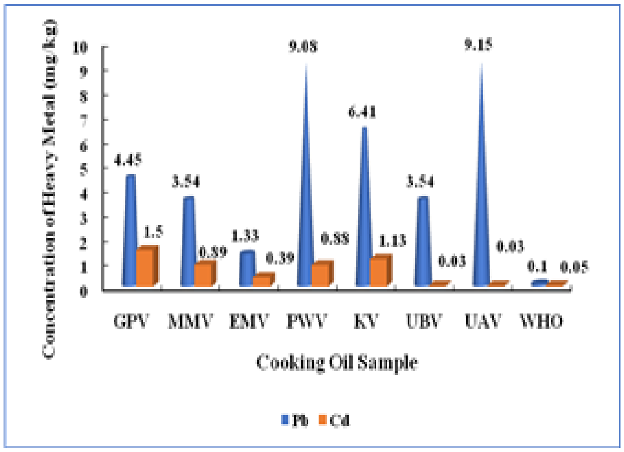

Figure 7: Comparison of Pb and Cd levels in vegetable oil with WHO standard

Figure 7 showed the result of the concentration of Pb and Cd levels in vegetable oils which were commonly consumed in cooking oil. In comparison with a research work done by Farzin and Moassesi showed that Pb and Cd concentrations in UAV, UBV, EMV, MMV, PWV and GPV cooking oils were lower than the range.[13]This shows that the concentration of Pd and Cd were within same range. It was also compared with WHO standard and the concentrations of lead and cadmium were higher than the stipulated standard of WHO (0.1 mg/kg and 0.05 mg/kg respectively). And WHO has established a provisional tolerable weekly intake (PTWI) for Pb of 0.025 mg/kg of body weight and JECFA provisional tolerable weekly intake (PTWI) for Cd is 7 µg/kg body weight.[14] And excessive Pb and Cd exposure may give rise to renal, pulmonary, hepatic, skeletal, reproductive effects and cancer.

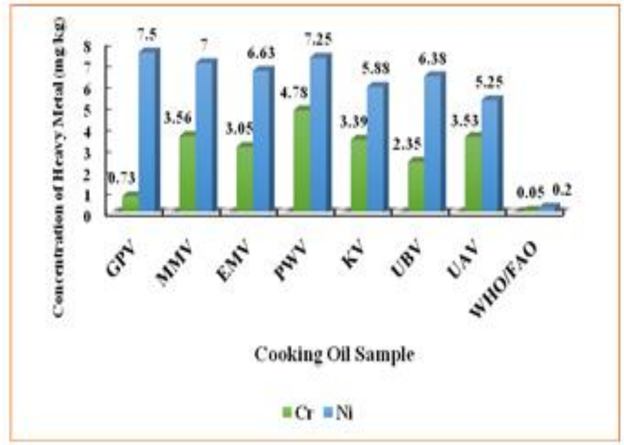

Figure 8: Comparison of Cr and Ni levels in vegetable Oil with WHO standard

The concentration of Cr and Ni levels in vegetable oil was compared with FAO/WHO standard as shown in Figure 8. The comparison showed that concentrations of Cr and Ni in the vegetable oil samples were higher than FAO/WHO standard (0.05 and 0.2 mg/kg respectively) . It was observed that the concentration of Cr in GPV cooking oil was lower than the result reported by Mohammad et al. (2014) while MMV, EMV, PWV, KV, UMV and UAV cooking oils were higher and Ni levels of GPV, MMV, EMV, PWV, KV, UBV and UAV in vegetable oil were also higher than the one reported. This showed that the result above were higher than FAO/WHO standard.[15]. The potential harm posed by higher concentration of Cr in human body are skin rashes, upset stomach, ulcers, respiratory problems, weakened immune systems, kidney and liver damage, alteration of genetic material, lung cancer and ultimately death.[16]. And the permissible limit of Ni in oil is set by many national and international countries at level of 0.2mg/kg. Concentrations above this can cause liver and kidney damage in human body.[17]

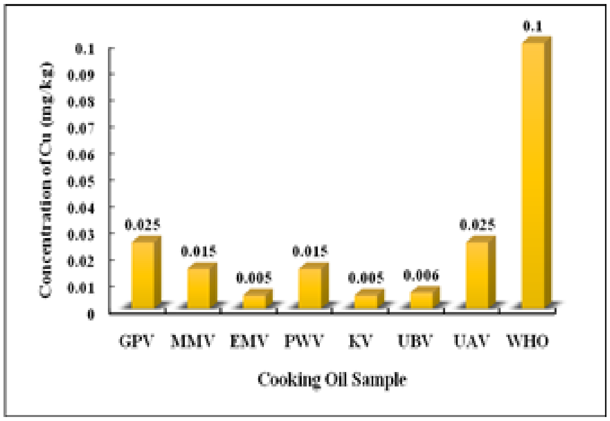

Figure 9: Comparison of Cu level in cooking oil samples with WHO standard

The concentrations of Cu in GPV, MMV, EMV, PWV, KV, UBV and UAV cooking oils were within WHO recommended limit of 0.1 mg/kg. Also compared with previous studies reported by Sobukola et al. (2010) in the range of 0.002 - 0.006 mg/kg and its shown that concentration of Cu in EMV, KV and UBV cooking oils were within the levels obtained in cooking oils from Turkey while the concentration of GPV, MMV, PWV and UAV cooking oils were higher than the values reported in the previous work.[18] Cu is essential for human body but very high intake can cause adverse health effects such as irritation of the nose, mouth and eyes and it also causes headaches, stomachaches, dizziness, vomiting and diarrhea and deficiency in Cu leads to hypochromic anaemia, leucopenia and osteoporosis in children.[19]

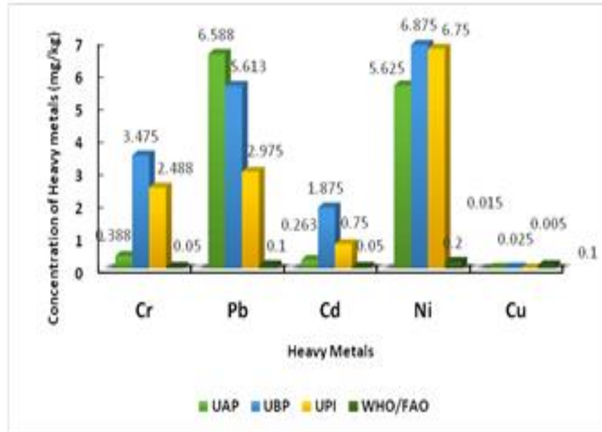

Figure 10: Comparison of heavy metal levels in palm oil with WHO/FAO standard

The comparison shown that the concentration of Cr, Pb, Cd, and Ni in unbranded Palm oil bought in two different open food markets were higher than WHO standard while Cu level is the only one that is within the recommended limit (figure 10). It is known that significant percentage of Nigerian population consume red palm oil both as nutritional and medicinal agents. It is good news that the palm oil samples analyzed contained these heavy metals of interest at concentrations lower than the WHO specification but if accumulated in the body over time may pose a risk to the health of consumers after many years [20]. For safety of human health, various regulatory organizations such as USP, BP, EPA, WHO, USEPA have set up parameters to limit the presence of heavy metals in palm oil. Parameters such as permissible daily exposure (PDE), rationale for reference doses (RfD), oral component limit (OCL) and parenteral component limits (PCL) are guidelines set to regulate elemental contaminations in different products including palm oil.

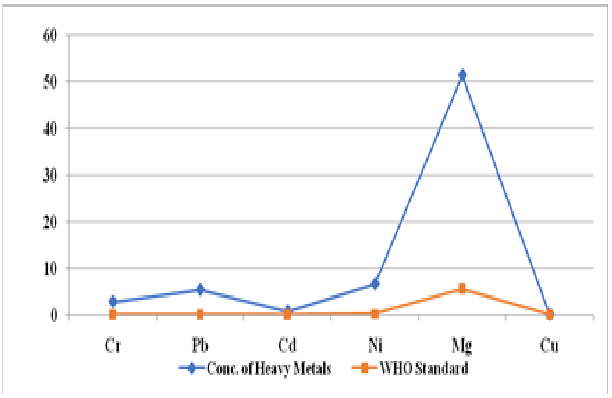

Figure 11: Comparison of the overall mean concentrations of heavy metals in cooking oils with WHO standard (mg/L)

The overall mean concentration of Cr, Pb, Cd and Ni in the cooking oils samples were higher than WHO standard while the overall mean of Cu in cooking oils samples were within the standard of WHO. And the overall mean that were higher than WHO standard such as Cr, Pb, Cd and Ni were very hazardous to human health.

HEALTH RISK ASSESSMENT

Health Risk Index (HRI)

The health risk index was calculated to know the ratio of the daily intake of metals to the oral reference dose. It was estimated using equation 2.0 above.

RfD is the oral reference dose for the metal (mg/kg/day) (Pb, Cr, Cd, Cu and Ni values were 0.004, 1.500, 0.001, 2.500 and 0.020 mg/kg/day, respectively), the average weight of adults consumption of cooking oil per day is 70kg. If the value of HRI is less than 1 then the exposed population is said to be safe. [22]

Table 1: Health Risk Index (HRI) of selected heavy metals in cooking oils

COOKING OIL	HEALTH RISK INDEX (HRI)				
	Cr	Pb	Cd	Ni	Cu
Vegetable oil	7.38x10-4	0.443	0.3411	0.1223	1.86x10-6
Soy oil	1.88x10-4	0.346	0.402	0.114	2.14x10-6
Coconut oil	5.57x10-4	0.538	0.313	0.179	7.14x10-7
Unbranded vegetable oil	7.0-x10-4	0.354	0.009	0.104	2.28x10-6
Unbranded palm oil	5.04x10-4	0.452	0.344	0.115	2.14x10-6
RfD	1.500	0.004	0.001	0.020	2.500

If the value of HRI is less than 1 then the exposed population is said to be safe.[23] It was observed from Table 1 that the HRI values for all the metals were less than 1 which shows that the consumption of the cooking oils does not pose toxicological risk, however, continuous consumption may put human health at risk.

CONCLUSION

62.40% of the respondents were aware of the likelihood of contamination of the selected heavy metals from the selected samples,30.70% were not aware while 6.90% of the respondents were not sure of the presence of these metals in these samples. Also, after the analysis, heavy metals were present in all the selected cooking oil samples and the heavy metals concentrations exceeded the available standards especially lead and cadmium which are very dangerous to human health except copper which was within the WHO/FAO standard. Some of the metals in the samples like Pb, Cd and Ni in unbranded palm oil and concentration of UBV in were within the recommended limits.

Monitoring of toxic metals in oil is essential in order to prevent excessive build-up of these pollutants in the human food chain

Appropriate measures must be taken byoil producing companies during the production process and products must be treated before marketing.

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