CANNING FOOD PROCESSES MAY BE A SOURCE OF THREAT TO THE CONSUMERS

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ABSTRACT

Many chemical elements that are present in the human diet are essential for human life at low concentrations but can be toxic at high concentrations and at chronic exposure. The aim of this study was to determine the levels of selected heavy metals viz, cadmium, lead, zinc, chromium and manganese in some canned food: Tuna chunks, Beans, Tomatoes and Mushroom that are sold in the supermarkets in Kakamega Town, in Kenya and compare them with the recommended international levels such as World Health Organization (WHO) and Kenya Bureau of Standards (KEBS). The levels of the analyzed heavy metal ions were done using atomic absorption spectrometer (AAS) in canned food products. The metal concentrations were found to be in the range of (0-0.007μg/kg) for Pb, (0.0017-0.0054μg/kg) for Cr, (0.0032-0.0042μg/kg) for Zn, (0-0062μg/kg) for Mn and (0-0.0035μg/kg) for Cd. Zinc results were higher than the WHO and KEBS permissible levels in food products. Although most samples had Lead metal concentration within permissible levels, mushroom which had the highest concentration of (0.0071μg/kg) was higher than this. Chromium had its concentrations below and within the permissible levels except in tomato paste that had the highest concentration of (0.0041μg/kg) above the permissible levels in all samples. Cadmium and Manganese levels were within the permissible levels in both samples. The results necessitate continuous monitoring of Zn and Pb levels and controlling of the canning process in canned food to obtain food safety. The study shows that Zn, Pb and Cr levels were higher than permissible levels and this is an important alarm in public health. From the results there is requirement for the continuous monitoring of Zn, Pb and Cr concentration for the control of the canning process in canned food for safety. We therefore, recommend further future studies in assessing the levels of these studied elements in human body and also selecting samples from a wide variety of the canned food. Comparison between fresh and frozen foods should be done to determine the exact concentration of metal elements in these food types.

Keywords: Canned food, threat, metals, permissible levels and samples.

1.0 INTRODUCTION

Food is a vital substance required by all organisms for the sustenance of life, and it's associated with functions, such as growth, development and maintenance of the body. Most food materials are obtained from plants and animals such as vegetables, fruits and grains etc. They provide the body with essential resources such as vitamins and minerals. Foods are typically classified according to readiness to consumption[1]. Some are consumed without further preparation after purchase (i.e. ready to eat food) and the other category requires further processing before consumption. Ready to eat food is the food that is ready for consumption at the selling point, which of recent has increased significantly due to the increased mobility, itinerary workers and low home-centered activities [1]. Canned foods may be affected by some contaminants during the canning process. These contaminants may include chemicals and microorganisms emanating from the environment[2]. Food contamination refers to the presence of harmful substances in food, which can cause consumer illness. The impact of chemical contaminants on consumer health and well-being is often apparent only after many years of processing and prolonged exposure at low levels, for example cancer. Unlike food-borne pathogens, chemical contaminants present in foods are often unaffected by thermal processing. Chemical contaminants can be classified according to the source of contamination and the mechanism by which they enter the food product. Some of these chemical contaminants include heavy metals like copper, lead, cadmium, among others, mycotoxins, organic pollutants like dioxins and acrylamide [3].

A heavy metal is described as any metallic element that is toxic at even low concentration. Heavy metals are distinct metals that can affect human life and health [3]. They form a major component of the environment. Their presence is unique as it is challenging to eliminate them from the environment. The exposure to these metals to humans is done through different pathways such as, ingestion, inhalation and skin contact [4]. Living nearby an industry or working in an industry also exposes the human health to these metals.

Trace elements are essential in the maintenance of human body metabolism. Nevertheless, trace amount of heavy metals is harmful and dangerous because they tend to bio-accumulate and bio-magnify. This bio-magnification and bio-accumulation increases the concentration of the heavy metals in a target organ with time until they become harmful and hazardous to human health[3]. This may lead to deficiencies in some nutrients and also resulting to Parkinson's disease, respiratory abnormalities, intestinal and abdominal problems, cancer, skin diseases, and damage of the central nervous system, reproductive failure and blood disorders such as clotting[4]. Exposure to high concentration of these heavy metals can cause dermatitis, vomiting, nausea, gastrointestinal infections and nausea[4]. In Kenya, there are several popular canned food products. However, the assessment of the safety of such products does not attract the attention of many researchers; therefore, there is limited information and data on their status. This study therefore was involved in the determination of heavy metal ions: Pb, Cd, As, Hg and traces metals Cu, Zn in canned food in Kenya and was able to compare them to the permissible exposure limits and further suggested preventive measures and alternatives to these foods to the policy and decision makers at the national level.

2.0 MATERIALS AND METHODS

2.1 Project design

The study involved three key steps to achieve the stated objectives i.e. sample collection and transportation to the laboratory, sample preparation and digestion in the laboratory and sample analysis using Atomic Absorption Spectrometer (AAS). Four food samples viz, Tuna chunks, baked beans, tomato paste and mushrooms were purchased from a popular supermarket (Tuskys) in Kakamega town in December 2018 in duplicate, (Figure 2.1). All the samples, (Figure 2.2) were labeled and stored in polyurethane cool-boxes. The different samples were transported to the analytical laboratory in the Department of Chemistry, University of Nairobi awaiting digestion and analysis.

Figure 2.1: The overview of the supermarket

Figure 2.2: Shelves containing the canned food in the supermarket

2.2 Sample preparation and digestion

Inorganic compounds are difficult to dissolve and they contain silicates and metal hydroxides while biological samples contain organic matter, fats and oils etc. Destruction of organic matter is of importance for successful elemental analysis. Most of the techniques used require a matrix in solution and therefore depending on nature of sample various acid and fuel treatment at high temperature is required.

Each 'food can' was opened and the contents mixed and homogenized. 10g of each sample was weighed and dried at high temperatures. The samples were then crushed in a mortar and pestle to a fine powder form. 5grams of each sample powder was then weighed and distributed to three different 250ml beakers.10ml of (HNO_3) was added to each beaker and digestion was carried out in the fume hood until first vigorous reaction (black residue appeared). Then 10 ml of Perchloric acid and 10ml of distilled water was added into each beaker, as shown in Figure 2.4 and the heating continued until the solutions were clear (yellow-orange) and no residue remained. This took 1.5-2 hours for each sample. Evaporation was done to acquire around 5ml of each sample and the solutions of the samples were transferred to 50ml volumetric flask and rinsed properly to ensure quantitative transfer of the sample and the solution diluted with distilled water to 50 ml mark.

All the glassware were cleaned and rinsed with distilled water prior to use. The stock solutions were prepared by taking the required amounts of Pb, Cd, Mn, Cr add Zn salts and dissolved in deionized water to give 1000mg/l standard solution. This was therefore, used to produce the calibration curve that was used in the calculations of the metals in the samples. Figure 2.3 shows the four different types of canned food that were analysed in this study.

Figure 2.3 The canned food samples analyzed

Figure 2.4 Digestion processes of the canned food samples

2.3 Sample analysis

The apparatus that were used in the this study include; 250ml beakers, 50ml volumetric flasks, Measuring cylinder, Watch glass, all the samples were weighed using the Fischer scientific A-160Analytical weighing balance instrument, Hot plate with a heat control knob and stirrer knob, Conical flask, Wash bottles, Pipettes, Gallen KampOven model OV-160 for drying all glassware, AAS machine (spectra AA.10,Varian 8061176), crucibles and muffle furnace. While the reagents used include; Nitric(v) acid, Perchloric acid, Distilled water, lead standards, cadmium standards, manganese standards, chromium standards and zinc standards.

The digested samples were placed in sample bottles that were previously washed thoroughly and rinsed with concentrated HNO_3 as shown in Figure 2.5. This was to prevent the ions from being adsorbed on the walls of the bottle. Figure 2.5).

Figure 2.5: Canned food samples ready for AAS analysis.

2.4 Developing the calibration curve

The calibration curve of the AAS was done by introducing water as blank to adjust the reading of the instrument. The standards' stock solutions were used to prepare different concentrations 0, 0.5, 1.0, 1.5, 2.5, 3.0 mg of heavy metals Cd, Pb, Zn, Mn and Cr. After calibration each sample was introduced into the instrument recording the steady readings obtained. The apparatus were washed after each introduction with water as a blank solution to make sure that the reading returns to its initial setting.

2.5 Principle of AAS

In the Atomic absorption spectrophotometer, absorption from gaseous atoms was measured and the liquid was atomized by the flame. The temperature was in the range of 2300-2400k, which was determined by the choice of the fuel used and oxidant and its effects ionization interferences encountered. In AAS a liquid sample was aspirated into a flame, evaporated and the remaining solid was atomized or simply broken into atoms in the flame, as shown in Figure 2.6. The excited atoms vaporize and emit light with the same frequencies absorbed by analyte in the flame used. The detector measured the amount of light that passed through the flame and amplified it and then it was recorded in readout.

The stock solutions were prepared by taking the required amounts of pure 1.5985g Pb $(NO)_2$, 2.036g $Cd(Cl)_2$, 1.245g (ZnO), 7.696g $(Cr(NO_3)_3.9H_2O)$, 3.6077g $(Mn(Cl)_2.4H_2O)$ salts and dissolved in deionized water to give 1000mg/L standard solutions.

Figure 2.6: A photo showing a process of sample injection into the AAS machine

3.0 RESULTS AND DISCUSSION

3.1 Introduction

The mean concentration levels of Cd, Pb, Mn, Cr and Zn ions in the canned food samples were analysed in this study. The samples were purchased from Kakamega Town in Kenya. They were then analysed in triplicate for metals ions and their concentrations are presented in terms of mean and standard deviation as shown in Table 3.1. The concentrations were obtained from the calibration curve based on the absorbance of the samples with unknown concentrations and confirmed by interpolation of the calibration curves in excel.

Table 3.1 Heavy metal ion concentrations in food samples (mean ±sd) mg/L

SAMPLE	Cd	Mn	Zn	Cr	Pb
A	BDL	BDL	0.0042±0.0001	0.0019±0.0011	BDL
B	BDL	0.0044±0.0006	0.0032±0.0001	0.0017±0.0001	BDL
C	0.0035±0.0001	0.0063±0.0016	0.0041±0.0004	0.0054±0.0006	0.0010±0.0007
D	0.0029±0.0002	0.0006±0.0009	0.0041±0.0004	0.0040±0.0003	0.0071±0.0015

Key: A = Tuna chunks, B = baked beans, C = tomato paste, D = mushrooms
BDL = Below Detection Limit

3.1.1 Levels of Cadmium metal ions in the food samples

The chronic durational oral minimal risk level (MRL) for Cd is 0.1µg/kg/day based on its renal effect[5]. If we take a 60 kg person, he needs 6µg/day to reach the permissible level which is lower than our results for Cd, whereas our ranges of Cd in our study was (BDL-0.0035±0.0001) mg /L which were lower than the permissible levels(0.006 mg/L). Tomato paste had the highest concentration of cadmium, (Table 3.1 and Figure 3.1), followed by mushroom. Baked beans and tuna chunks concentration were below detection limit (BDL) indicating that they contained cadmium element at a very low level. Canned food can harm human health in chronic use and this may be one of the risk factors for kidney diseases in the society.

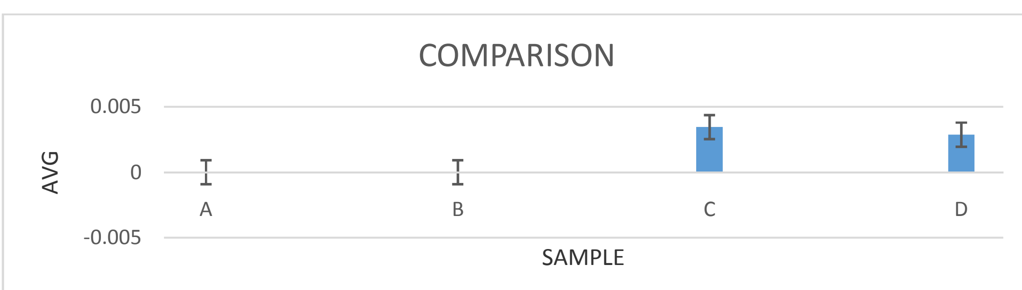

Figure 3.1 A graph representing the average concentration of cadmium element in the food samples.

3.1.2 Levels of Manganese metal ions in the food samples

Manganese (Mn) is a trace element important for good health in all living organisms. The WHO recommends permissible levels for Mn in foods to be in the range of, (0.02±0.0006 to 0.05±0.0016)mg/L. This element was not detected at all in tuna chunks, (Table 3.1 and Figure 3.2), however, tomato paste had the highest concentration of this metal closely followed by baked beans and mushrooms respectively (Figure 3.2). The study reveals that the concentration levels of Mn ions were below the permissible limits and levels as stipulated by ATSDR[6].

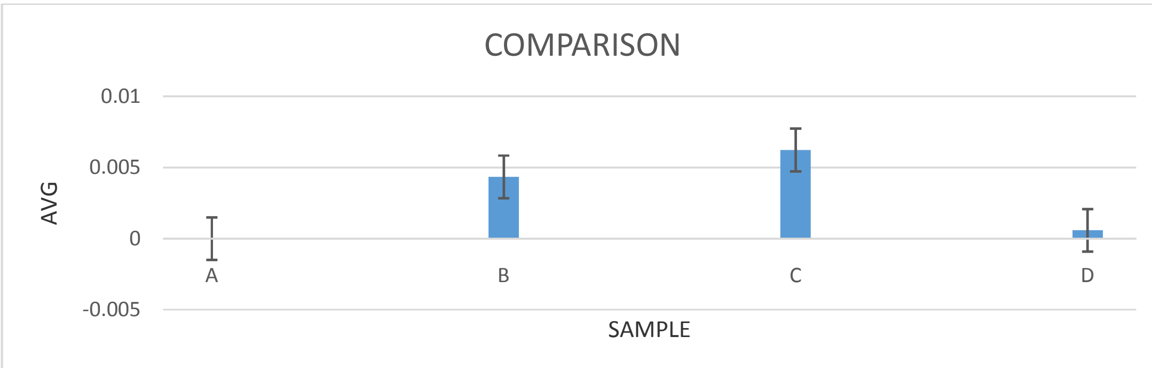

Figure 3.2 Graph representing the average concentration of manganese element in the samples.

3.1.3 Zinc metal ions' levels in the canned food samples.

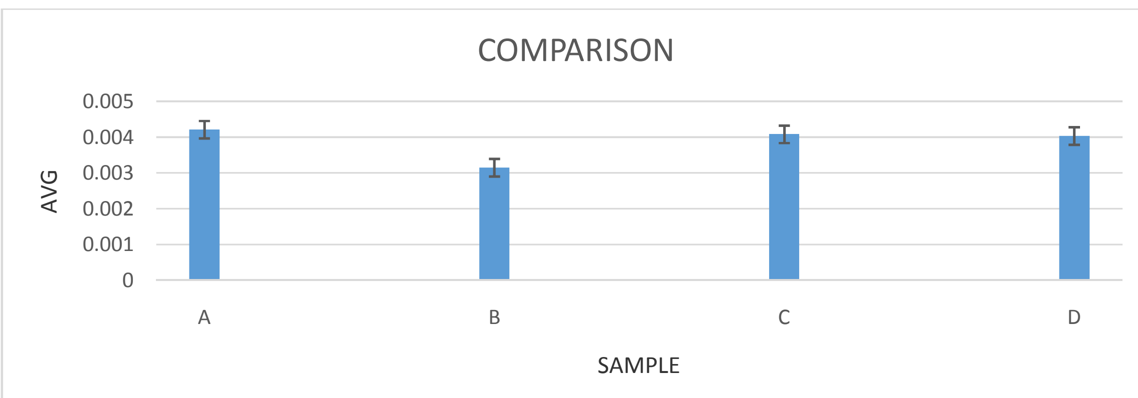

Figure 3.3 Graph representing the average concentration of zinc element in the samples.

Permissible levels of Zn in food as reported by WHO is 8mg/day for female and 11mg/day for male. This is an equivalent of 0.005 to 0.015 mg/ permissible levels. In our study the concentration of Zn was in the range of (0.0032±0.0001 to 0.0042±0.0001) mg/L, which is higher than the permissible levels. All the samples had a higher concentration of zinc element with tuna chunks having the highest concentration, followed by tomato paste and mushrooms both with equal concentrations (Table 3.1) and finally baked beans.

3.1.4 Chromium metal ions' levels in the canned food samples.

The permissible Chromium levels in food as per WHO/FOA are 0.005mg/L. The metal ion concentrations in the canned food samples in this study were all below the permissible level stipulated by WHO except in Tomato paste which was slightly higher (Table 4.9 and Figure 3.4). Chromium exposure above maximum allowable limits can cause irritation of the skin for short periods and for long periods it can cause damage to the liver and nerve tissues and it's also carcinogenic [7].

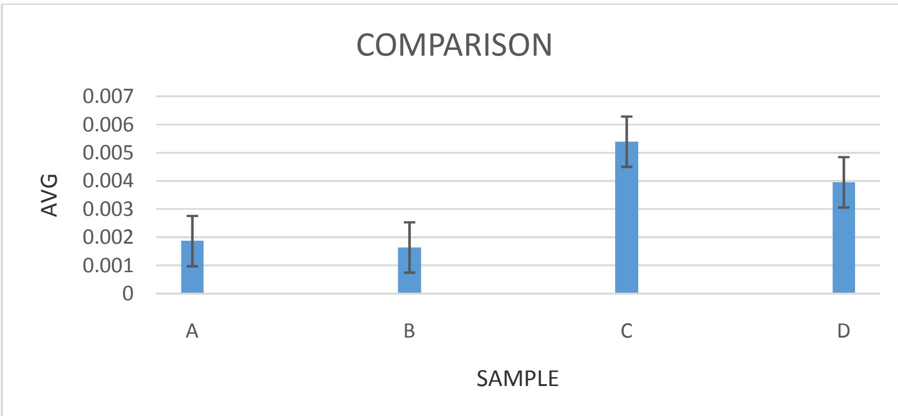

Figure 3.4 A graph showing the average concentration of chromium element in the samples. The error bars represent ±SD

3.1.5 Lead metal ions' levels in the canned food samples

Expert committee on food additives suggests a provisional tolerable intake of 400-500µg Pb per week for humans. However, the Food and Drug Administration,(FDA) has set an action of 0.5µg/ml for Pb in products intended for use by infants and children[8]. The Food and Agricultural Organization, FAO has set1mg/kg as maximum levels of Pb in canned foods [1]. In relation to our study, the maximum level of Pb was,(0.007±0.0015)mg/L, (Table 3.1) which was higher than the permissible level of Pb in canned food as stated by FAO. Mushrooms had the highest concentration of Pb above the permissible levels of 0.001mg/L. tomato paste had the least of the concentration, (Figure 3.1) but still within the permissible levels. Baked beans and tuna chunks concentrations were below the detection limit (BDL).

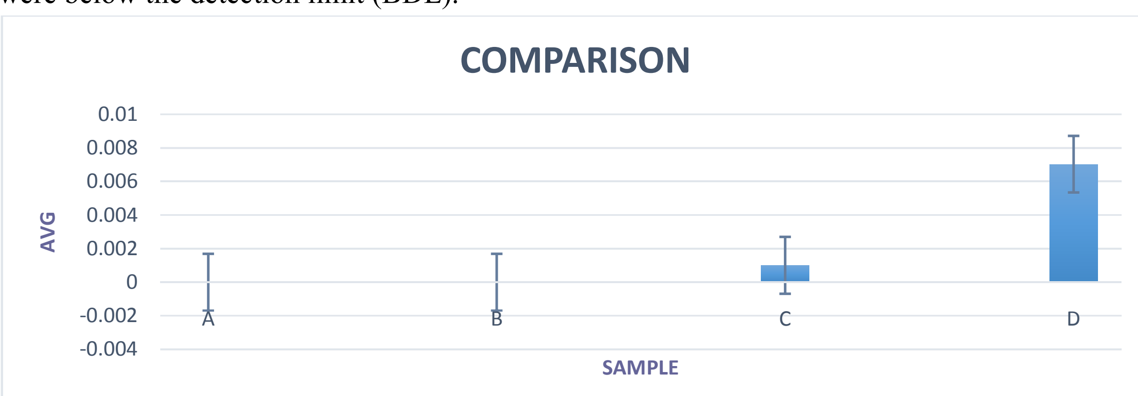

Figure 3.5 graph representing the average concentration of lead element in the samples. The error bars represent ±SD

3.2 Average Concentration of all the metal elements in the canned food samples

The average contents of heavy metal ions in the canned food samples were found to be 0.0011±0.0001 mg/L for Cd, 0.0021±0.00o7 mg/L for Mn, 0.00390±0.0035 mg/L for Zn, 0.0032±0.0065 mg/L for Cr and BDL for Pb respectively as shown in Table 3.2 and Figure 3.6. Zn had the highest total concentration, followed by Cr, Mn and Cd respectively and finally Pb with the least concentration, (Figure 3.6).

Cadmium has no known biological function in human, it mostly accumulates in kidneys and liver and has a long life (4-19) years. Lead is a toxic metal, even in low concentration. It causes health hazards since it is not biodegradable and it may cause kidney damage as mentioned in Korfali[9]. Its presence in the canned food may be due to use of Pb in product package materials or due to absorbed lead by plants.

In general, baked beans had the lowest concentration of Pb as compared to the other canned food samples that were analyzed in this study. The results in Table 3.1 agree with a study conducted in Riyadh to measure Pb concentration levels in canned beans reported as 0.019µg/g[10].

Table 3.2 average concentration of metal elements

Metal Element	Average
Cd	0.0011±0.0001
Mn	0.0021±0.0007
Zn	0.0039±0.0035
Cr	0.0032±0.0065
Pb	BDL

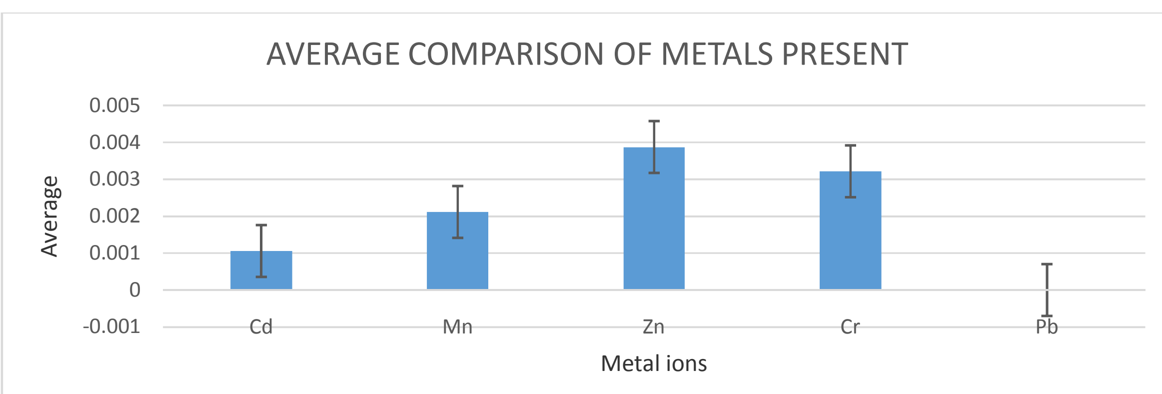

Figure 3.6 A graph of average concentration versus each sample. The error bars represent ±SD

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

In this study heavy metal ion concentrations, (essential and toxic) were analysed in different canned food samples purchased in December 2018 from a supermarket in Kakamega County in Kenya. Zinc and Lead ion concentrations were higher than WHO and KEBS permissible levels in food products. This is an important issue in public health for food safety and heavy metals accumulation in the human body. Although most samples in the test for Lead metal were within permissible levels, mushroom had the highest concentration of (0.0071µg/kg) higher than the permissible levels. Chromium had its concentrations below and within the permissible levels except in tomato paste that had the highest concentration of (0.0041µg/kg) above the permissible levels in all samples. Cadmium and Manganese levels were within the permissible levels in all the samples.

4.2 Recommendations

From the findings of the current work, the following recommendations were suggested:

1. The results necessitate continuous monitoring of Cr and Pb levels and controlling of the canning process in canned food to obtain food safety.
2. The assessment and correlation of the environmental exposure levels of canned food elements with human biological biomarkers or adverse effect can be done in further studies.
3. With the concentration of Cr and Pb exceeding the maximum permissible limits in some canned food samples, other technological methods that is cost effective should be employed to reduce these contaminants during the canning process.
4. NEMA, WHO and KEBS should set up policies and strictly enforcement existing regulations to avoid noncompliance.
5. Periodic monitoring of the canned food by researchers is necessary.

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