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The Effect of Heat on the Release of Lead from Kitchen Utensils in Different Types of Materials: A Case Study

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Abstract:

Lead, a heavy metal with atomic number 82, is characterized by a bluish-grey malleable texture, and its stable +2 oxidation state. Despite its reduced usage in visible applications like paint, lead remains present in various materials. Contamination sources range from retained bullets to leaded crystal glassware. Individuals may ingest up to 2 milligrams of lead daily, predominantly through the gastrointestinal tract. Children, more susceptible to oral ingestion, face heightened toxicity risks. Fine lead dust particles can be absorbed up to 90%, impacting the bloodstream, soft tissues, and bones. Understanding lead's pathways and effects is crucial for safeguarding public health. This study aim to examine effect of heat on the release of lead from kitchen utensils.The study assessed household containers, categorizing them as new and old, and further classified them into aluminum, stainless steel, and brass types, totaling 18 variations. Testing involved using a lead kit to check for contamination. Additionally, the research examined how temperature affected lead leakage, conducting tests from 30 to 200 degrees Celsius with deionized water in cleaned containers to prevent ion exchange. The tests were done using lead test kit. The study classified household containers into new and old, further dividing them by material: aluminum, stainless steel, and brass. New containers showed no lead contamination, while some old containers, like aluminum cooking pots and stainless-steel pans, had lead traces. The research also explored temperature's effect on lead leakage, finding both aluminum and stainless-steel cooking pots leaked at all temperatures. Overall, material type, container age, and temperature influence lead contamination, highlighting the importance of safe container choices

Keywords **—lead, kitchen container, utensils, heavy metal**

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Background

Lead is a heavy metal in Group 4 of the periodic table. It has an atomic mass of 207.22 g/mol and an atomic number of 82. Its melting point is 327 degrees Celsius, and its boiling point is 1,740 degrees Celsius. It has a density of 11.34. Lead is a bluish-grey metal with a soft and malleable texture. It melts easily and can be shaped into various forms as needed. It has poor electrical conductivity but is resistant to corrosion. It is slightly soluble in cold water and hot water. Lead can have various oxidation states, including +1, +2, and +4, but it is most commonly found in the +2 state, which is considered the most stable. Lead compounds are divided into two types: inorganic lead and organic lead. Lead is a heavy bluish-grey metal with properties that make it pliable into various shapes, which makes it widely useful. Due to the dangers associated with lead, its use has been reduced, especially in visible applications such as house paint and gasoline. However, there are still many materials that contain lead as a component, such as solder, batteries, ink, paint, and plumbing pipes. Lead compounds can be found in the air, water, and soil. [1,2] Lead is a commonly found contaminant in the environment. In the past, children would get lead poisoning from ingesting house paint or handling objects coated with such paint. Nowadays, lead content in paint has been reduced. Significant sources of adult lead poisoning come from industries such as battery manufacturing and other facilities with wide use of lead, like the electronics and computer industries. The general population may be exposed to lead through the air, often contaminated with lead from the use of tetraethyl lead in car fuel. Additionally, there are numerous other sources that may contribute to lead poisoning, including retained lead bullets in the body, work in shooting ranges, herbal medicines, ink, face powder ("thanakha"), ceramics containing lead, lead plumbing pipes, battery products, and food contaminated with lead. Lead is also found in various everyday items such as wine, engines that use lead as a component, leaded crystal glassware, lead type used in printing, lead curtain weights, and toys' paint. Lead is an element that is pervasive in the general environment.[3,4]

Normally, adults ingest about 150 micrograms (ug) of lead with their food daily. Children may ingest approximately 100 ug of lead per day with their food and about 100 ug of lead through drinking water. Additionally, people also receive lead through inhalation. In general, the air we breathe may contain around 1-2 ug of lead per cubic meter (ug/m³). It is estimated that if the lead concentration in the air is 1 ug/m³, it can lead to an increase of 1 ug/dl of lead in the blood. In summary, an individual may ingest about 0.1-2 milligrams (mg) of lead daily. In this amount, approximately 75% is ingested through the gastrointestinal tract, and 25% is ingested through inhalation.The absorption of lead through the gastrointestinal tract is about 10% for adults, while children may absorb more, up to 40%. This means that children who ingest lead-contaminated substances orally may experience more toxicity.

As for lead that enters through the respiratory system, the finer the lead dust particles, the greater the absorption. Lead dust particles smaller than 0.5micrometers (um) can be absorbed up to 90%. The distribution of lead in the body is divided into three compartments. One part of the lead goes into the bloodstream, of which 95% binds to red blood cells (RBCs), with a quantity in the blood of about 2 mg and a half-life of 35 days. Another part is distributed to soft tissues in the body such as the liver, kidneys, and nervous system. The exact amount of lead accumulated in this part is not yet certain, but it may be around 0.6 mg. Some studies suggest it could be as high as 10% of the lead accumulated in the body. The lead in this part has a half-life of approximately 40 days. The largest portion of lead accumulation in the body is in the bones, with an estimated quantity of about 200 mg. Some reports suggest that about 90% of the lead in bones has a half-life of approximately 20-30 years. The excretion of lead from the body is mostly through the kidneys, with approximately 75% being eliminated, which is equivalent to 36 ug per day. The remaining 25%, or 12 ug per day, is excreted through urine, hair, sweat, and nails.[3,5]

Lead can enter the body through three pathways: Oral Route: This occurs when lead is ingested through food and water that is contaminated with lead. Nasal Route: This happens when lead is inhaled through the nose, typically in the form of dust or fumes. The size and composition of lead particles in the air can vary depending on the proximity to sources of lead emissions. Dermal Route: Lead can also enter the body through the skin, especially in areas where the skin is in prolonged contact with a high concentration of lead-containing substances[5,6]

When lead enters the body, it affects various systems within the body. The most significant systems affected include the nervous system, both central and peripheral. This is particularly impactful in young children, where it can have repercussions on brain development and learning abilities. In adults, it may lead to symptoms such as fatigue, kidney damage, high blood pressure, and abnormalities in the reproductive system, among others. [7,8,9]

Due to its ability to be easily melted, lead, being a heavy metal, can be shaped into various forms, making it versatile for a wide range of applications. One of these applications includes using lead as a component in the production of containers used for food preparation.

Objective:

To examined lead contamination in household containers

Methodology:

Type of Household Containers

The study examined lead contamination in household containers by categorizing them into two main types: new household containers and old household containers. Additionally, household containers were further categorized into three types, totaling 18 types in total. These included aluminum household containers (consisting of double-handled pans, cooking pots, handled frying pans, and Korean-style grilling pans), stainless steel household containers (including double-handled pans, handled frying pans, cooking pots, and Korean-style grilling pans), and brass household containers (comprising egg pans and Korean-style pots). The new household containers represented those currently available in the general market, while the old household containers were those that had been in use for an extended period and did not adhere to any specific standards.

Testing for Contamination in Household Containers

A total of 18 types of household containers, including both new and old ones, were subjected to testing for contamination. This was accomplished by using a lead testing kit to conduct the examinations.

Testing the Effect of Temperature on the Leakage of Lead Substance.

The study investigates the impact of temperature on the leakage of lead substance. This is conducted by testing at temperatures of 30, 50, 100, 150, and 200 degrees Celsius. The process involves using deionized water in various types of household containers that have been thoroughly cleaned. The water is heated until boiling, then maintained at the desired temperature for examination, ensuring no ion exchange occurs.

Results

Testing for Contamination in Household Containers

The testing for contamination in household containers was conducted by categorizing the containers into two main types: new household containers and old household containers. Additionally, the

household containers were further divided into three materials - aluminum containers (including double-handled pans, cooking pots, handled frying pans, and Korean-style grilling pans), stainless steel containers (including double-handled pans, handled frying pans, cooking pots, and Korean-style grilling pans), and brass containers (including egg pans and Korean-style pots). The results of the testing are presented in Table 1.

Table 1:Results of Contamination Testing in Household Containers.

Type of Material	Container	Results of Lead Substance Testing in Containers	
		Positive	Negative
Aluminum	New double-handled pan		✓
	Old double-handled pan		✓
	New cooking pot		✓
	Old cooking pot	✓	
	New single-handled frying pan		✓
	Old single-handled frying pan	✓	
	New Korean-style grilling pan		✓
	Old Korean-style grilling pan		✓
Stainless			✓
	New double-handled pan	✓	
	Old double-handled pan		✓
	New single-handled frying pan		✓
	Old single-handled frying pan		✓
	New cooking pot	✓	
	Old cooking pot		✓
	New Korean-style grilling pan		✓
Brass container	Old Korean-style grilling pan		✓
	New egg pan		✓

From Table 1, it was found that the contamination of lead substance in both types of household containers, old and new, differed. Among the three common types of new household containers (aluminum, stainless steel, and brass) available in the general market, no lead contamination was detected. On the other hand, some types of old household containers were found to have lead contamination, including aluminum cooking pots, single-handled aluminum frying pans, double-handled stainless-steel pans, and stainless-steel cooking pots.

The Effect of Temperature on the Leakage of Lead Substance

The study investigated the effect of temperature on the leakage of lead substance. The temperatures examined were 30, 50, 100, 150, and 200 degrees Celsius. The results of the study are presented in Table 2.

Table 2:Effect of Temperature on the Leakage of Lead Substance in Household Utensils (Old Type)

Type of Container	The Leakage of Lead Substance in Household Utensils				
	30 ˚C	50 ˚C	100 ˚C	150 ˚C	200 ˚C
Aluminum Cooking Pot	✓	✓	✓	✓	✓
Aluminum Skillet with Single Handle		✓	✓	✓	✓
Stainless Steel Skillet with 2 Handles		✓	✓	✓	✓
Stainless Steel Cooking Pot	✓	✓	✓	✓	✓

Based on the test results for lead leakage in the old kitchen containers at temperatures of 30, 50, 100, 150, and 200 degrees Celsius, it was observed that both the aluminum cooking pot and the stainless-steel cooking pot exhibited lead leakage at all temperatures. As for the aluminum skillet with a single handle and the stainless-steel skillet with 2 handles, lead leakage was observed at temperatures of 50, 100, 150, and 200 degrees Celsius.

Conclusion

From the conducted tests, several conclusions can be drawn as following points: 1) Contamination in Household Containers: The household containers were categorized into two main types: new and old. Further classification was made based on the material: aluminum, stainless steel, and brass. Among the three common types of new household containers available in the general market (aluminum, stainless steel, and brass), no lead contamination was detected. Some types of old household containers were found to have lead contamination. These include aluminum cooking pots, single-handled aluminum frying pans, double-handled stainless-steel pans, and stainless-steel cooking pots. 2) Effect of Temperature on Lead Leakage: The study examined the influence of temperature on the leakage of lead substance. Temperatures ranging from 30 to 200 degrees Celsius were investigated. 3) Results for old kitchen containers: Both the aluminum cooking pot and the stainless-steel cooking pot exhibited lead leakage at all temperatures. The aluminum skillet with a single handle and the stainless-steel skillet with two handles showed lead leakage at temperatures of 50, 100, 150, and 200 degrees Celsius. In summary, the study shows that the type of material and whether the container is old or new significantly affects lead contamination. New household containers made of aluminum, stainless steel, and brass did not show lead contamination. However, some old household containers, particularly those made of aluminum and stainless steel, exhibited lead contamination. Additionally, the temperature of the container also plays a role in lead leakage, with higher temperatures leading to increased contamination.

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