



Investigation of Lead and Cadmium Contamination Levels in Selected Canned Tomato Paste Products Sold in the Libyan Market

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دراسة مستويات تلوث الرصاص والكاديوم في منتجات مختاره من معجون الطماطم المعلب المباعة في السوق الليبية

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Abstract:

Heavy metal contamination in food products is a major environmental and public health concern due to the toxic and bioaccumulative properties of these elements. This study aimed to determine lead (Pb) and cadmium (Cd) concentrations in canned tomato paste products available in the local market of Derna, Libya, and to evaluate their compliance with permissible limits. Twelve commercially available samples representing different brands and countries of origin were collected from local markets and coded STB01–STB12. The samples were prepared using wet acid digestion with concentrated nitric acid and analyzed using Atomic Absorption Spectroscopy (AAS). Lead concentrations ranged from 0.007 to 0.094 mg/L, while cadmium concentrations ranged from 0.001 to 0.090 mg/L. All samples showed lead concentrations below the WHO/FAO permissible limit of 0.1 mg/L. However, three samples exhibited cadmium concentrations exceeding the recommended limit of 0.05 mg/L. The elevated cadmium levels may be associated with environmental contamination, raw materials, processing conditions, or packaging materials. The findings highlight the need for continuous monitoring and periodic heavy metal analysis of canned food products to ensure quality control and consumer safety.

Keywords: Heavy metals, Atomic Absorption Spectroscopy (AAS), Lead, Cadmium, Canned tomato paste.

المخلص:

يُعتبر تلوث المنتجات الغذائية بالمعادن الثقيلة قضية بيئية وصحية عامة رئيسية بسبب الطبيعة السامة وخصائص التراكم البيولوجي لهذه العناصر. هدفت هذه الدراسة إلى تحديد تراكيزات الرصاص والكاديوم في منتجات معجون الطماطم المعلب المتوفرة في السوق المحلي لمدينة درنة، ليبيا، وتقييم مدى امتثالها للحدود المسموح بها دوليًا. تم جمع اثني عشر عينة من معجون الطماطم المعلب المتاح تجاريًا بشكل عشوائي من الأسواق المحلية ثم تمت عملية الهضم باستخدام حمض النتريك المركز ومعرفة التركيز بواسطة جهاز الطيفي الذري. أظهرت النتائج أن تراكيزات الرصاص تراوحت بين 0.007 إلى 0.094 جزء من مليون، بينما تراوحت تراكيزات الكاديوم بين 0.001 إلى 0.090 جزء من مليون. احتوت معظم العينات على مستويات من الرصاص أقل من الحد الأقصى المسموح به من قبل منظمة الصحة العالمية، ومع ذلك، أظهرت

عدة عينات تركيزات من الكاديوم تفوق الحد الموصي به من منظمة الصحة العالمية (0.05 جزء من مليون)، وقد يُعزى ذلك إلى التلوث البيئي، أو المواد الخام، أو ظروف المعالجة، أو مواد التعبئة والتغليف. وتشير النتائج إلى أن غالبية عينات معجون الطماطم المفحوصة كانت آمنة نسبيًا فيما يتعلق بتلوث الرصاص، في حين أن المستويات المرتفعة من الكاديوم في بعض العينات قد تشكل خطرًا صحيًا محتملًا. لذلك، يُوصى بشدة بالاستمرار في مراقبة المنتجات المعلبة، وإجراء تحاليل دورية للمعادن الثقيلة، واتباع إجراءات رقابة نوعية أشد صرامة للمنتجات المستوردة والمحلية لضمان سلامة المستهلك وحماية الصحة العامة.

الكلمات المفتاحية: العناصر الثقيلة، جهاز مطياف الامتصاص الذري، الرصاص، الكاديوم، طماطم معلبة.

Introduction:

Tomato paste, and tomato-based sauces are widely consumed food products used to enhance the color, flavor, and nutritional value of various foods. They are produced from fully mature tomatoes through several processing stages, including juice extraction, concentration, conditioning, and packaging. During processing and storage, particularly when metallic cans are used, heavy metals may migrate into food products and consequently affect their safety and quality [1].

Heavy metals are persistent environmental contaminants that can accumulate in soil, water, food, and living organisms [2]. Some mineral elements, such as sodium (Na), calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), and phosphorus (P), are essential for normal physiological functions. In contrast, toxic metals such as lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As) may pose serious health risks even at relatively low concentrations [3]. Exposure to these metals can induce oxidative stress and cellular damage, affecting lipids, proteins, and DNA and potentially contributing to various chronic health effects [4].

Heavy metals may originate from both natural and anthropogenic sources. Natural processes, including volcanic activity and weathering, can release metals into soil and surface water, whereas anthropogenic activities such as industrial operations, mining, transportation, and agricultural practices represent important sources of environmental contamination [5,6,7]. Consequently, heavy metals may enter the food chain through contaminated environmental media and raw materials.

Food processing and packaging can provide additional pathways for heavy metal contamination. In particular, heavy metals may migrate from metallic packaging materials into canned food during processing and storage. Previous studies have reported detectable concentrations of lead and cadmium in various canned food products, with some samples exceeding established permissible limits [8,9,10]. Therefore, monitoring heavy metals in processed foods is important for evaluating food safety and potential consumer exposure.

Among the heavy metals of greatest concern are lead (Pb) and cadmium (Cd). Both elements can enter food at different stages of production, processing, and storage [1]. Chronic exposure to cadmium may result in its accumulation in organs such as the kidneys and may adversely affect the skeletal, nervous, and immune systems. Lead exposure can affect the nervous and circulatory systems and has been associated with several adverse health effects [11,12]. Food consumption is considered an important route of human exposure to these contaminants, highlighting the need for regular monitoring of their concentrations in food products [13,14].

Given the widespread consumption of processed and canned foods, assessing their safety in local markets is important. However, information regarding the levels of lead and cadmium in commercially available canned tomato paste in Derna, Libya, remains limited. Therefore, the present study aimed to determine the concentrations of Pb and Cd in commercially available tomato paste products collected from different markets in Derna city. Twelve tomato paste samples were analyzed using Atomic Absorption Spectroscopy (AAS), and the measured concentrations were compared with relevant permissible limits to assess the safety of these products for consumers.

Materials and Methods:

Sample Collection:

Twelve commercially available canned tomato paste samples representing different brands and countries of origin were randomly collected from local markets in Derna, Libya. The samples were coded STB01–STB12 and transported to the Chemistry Laboratory. They were stored in a clean and dry place until digestion and analysis, following the procedure described by [15]. Details of the collected samples are presented in Table 1.

Table (1): Commercial canned tomato paste samples analyzed in this study.

Sample NO	Product name	Country of origin
STB 01	Gallo	Libya
STB 02	Al-Safwa	Libya
STB 03	Ghalia	Italy
STB 04	Aya	Italy
STB 05	Al-Bustan	Italy
STB 06	Good	Italy
STB 07	Lamar	Libya
STB 08	Tawfiq	Italy
STB 09	Al-Taybat	Libya
STB 10	Al-Fakhama	China
STB 11	Emmar	Italy
STB 12	Al-Zahrat	Italy

Sample Preparation and Acid Digestion:

All chemicals used were of analytical reagent grade, and ultrapure water was used throughout the experimental procedures. All plastic and glassware were thoroughly cleaned and rinsed three times with ultrapure water before use.

For the digestion procedure, 0.5 g of each tomato paste sample was accurately weighed into a 150 mL beaker, followed by the addition of 25 mL of distilled water. Subsequently, 5 mL of concentrated nitric acid (HNO_3) was added slowly. The beakers were covered with watch glasses and heated on a hot plate until clear solutions were obtained.

The resulting solutions were filtered using a vacuum filtration system and allowed to cool. Each digest was then transferred quantitatively into a 50 mL volumetric flask and diluted to the mark with distilled water. [16].

The heavy metals analysis:

The concentrations of lead (Pb) and cadmium (Cd) in the prepared tomato paste samples were determined using an Atomic Absorption Spectrophotometer (AAS) at the central laboratory, Faculty of Science, Omar Al Mukhtar University

Results:

Quantitative spectroscopic analysis was performed to determine the concentrations of lead (Pb) and cadmium (Cd) in twelve prepared commercial tomato paste sample solutions using atomic absorption spectrometry (AAS). The analytical results, expressed in milligrams per liter (mg/L), equivalent to parts per million (ppm), are presented in Table 2 and Figure 1 and Figure 2.

Table (2): The mean concentration of lead and cadmium in tomato paste in mg/L (ppm).

Sample No	Pb (mg/L) mean $\pm$ SD	Cd (mg/L) mean $\pm$ SD
STB 01	0.047 $\pm$ 0.002	0.027 $\pm$ 0.001
STB 02	0.059 $\pm$ 0.011	0.032 $\pm$ 0.012
STB 03	0.056 $\pm$ 0.002	0.042 $\pm$ 0.011
STB 04	0.007 $\pm$ 0.000	0.010 $\pm$ 0.003
STB 05	0.060 $\pm$ 0.003	0.067 $\pm$ 0.001
STB 06	0.073 $\pm$ 0.001	0.009 $\pm$ 0.011
STB 07	0.032 $\pm$ 0.011	0.022 $\pm$ 0.002
STB 08	0.070 $\pm$ 0.002	0.090 $\pm$ 0.002
STB 09	0.094 $\pm$ 0.002	0.076 $\pm$ 0.001
STB 10	0.048 $\pm$ 0.001	0.006 $\pm$ 0.011
STB 11	0.040 $\pm$ 0.011	0.001 $\pm$ 0.002
STB 12	0.082 $\pm$ 0.001	0.011 $\pm$ 0.003
WHO/FAO [17]	0.1	0.05

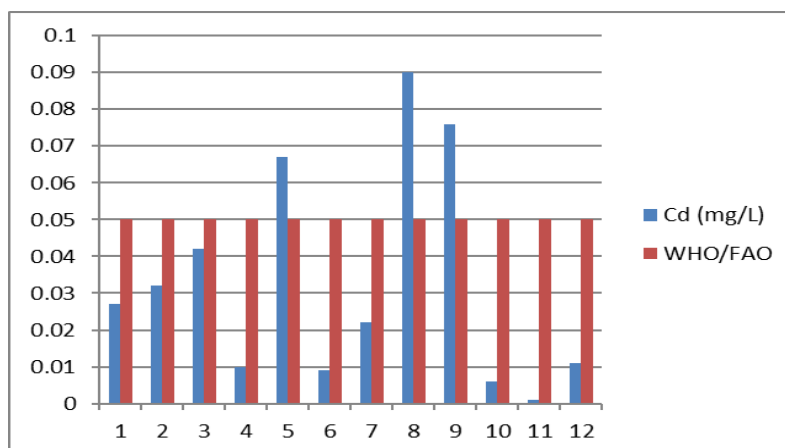


Figure (1): The cadmium concentration in tomato paste samples.

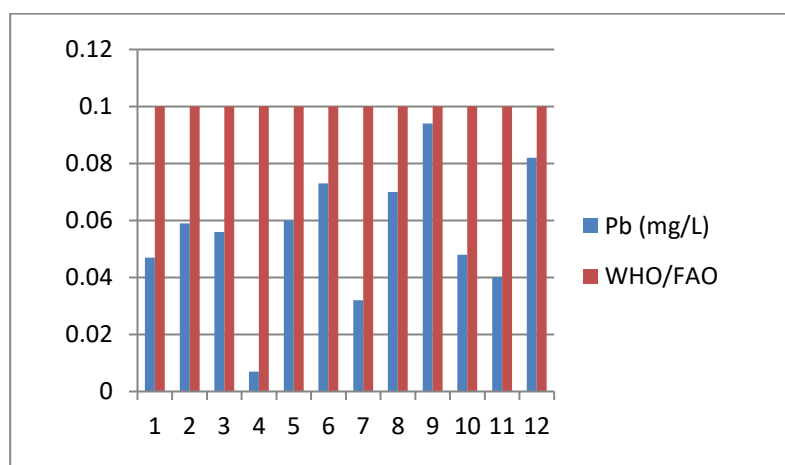


Figure (2): The lead concentration in tomato paste samples.

Discussion:

The concentrations of lead (Pb) and cadmium (Cd) in the 12 tomato paste samples ranged from 0.007 to 0.094 mg/L and from 0.001 to 0.090 mg/L, respectively. For Pb, the highest concentration was observed in sample STB 09 (0.094 ± 0.002 mg/L), whereas the lowest concentration was detected in STB 04 (0.007 ± 0.000 mg/L). Although all measured Pb concentrations were below the WHO/FAO permissible limit of 0.1 mg/L, the relatively high concentration observed in STB 09 indicates the presence of Pb contamination in the analyzed samples.

In contrast, Cd concentrations ranged from 0.001 ± 0.002 mg/L in STB 11 to 0.090 ± 0.002 mg/L in STB 08. The WHO/FAO maximum permissible limit for Cd is 0.05 mg/L. Three samples (STB 05, STB 08, and STB 09) exceeded this limit, with concentrations of 0.067, 0.090, and 0.076 mg/L, respectively. The occurrence of Cd concentrations above the permissible limit in these samples may be associated with contamination originating from agricultural soils, irrigation water, phosphate fertilizers, industrial emissions, or processing and packaging materials, as previously reported by [1].

The generally low standard deviation (SD) values indicate good consistency among replicate measurements and support the reliability of the analytical results. The detection of Cd above the permissible limit in three samples is of particular concern because prolonged dietary exposure to Cd may pose potential health risks. Therefore, continuous monitoring of heavy metals in commercially available tomato paste, together with appropriate quality-control measures during cultivation, processing, and packaging, is recommended.

Conclusion:

The findings of this study demonstrated variations in the concentrations of lead (Pb) and cadmium (Cd) among the investigated canned tomato paste samples. The concentrations of Pb in all tested samples were below the permissible limit established by the relevant standards. In contrast, Cd concentrations varied among the samples, with three samples exceeding the specified permissible limit of 0.05 mg/L, while the remaining samples were within the permissible limit. These findings highlight the importance of continued monitoring of heavy metals, particularly Cd, in canned tomato paste products to assess potential contamination and ensure food safety and compliance with established

standards.

References:

1. David I, Nela ŞM, Balcu I, Berbentea F. The heavy metals analyses in canned tomato paste. *J Agroaliment Proc Technol*. 2008; 14:341-345.
2. Sarker A, Kim JE, Islam ARMT, Bilal M, Rakib MRJ, Nandi R, et al. Heavy metals contamination and associated health risks in food webs—a review focuses on food safety and environmental sustainability in Bangladesh. *Environ Sci Pollut Res*. 2022;29(3):3230-3245.
3. Karimi A, Naghizadeh A, Biglari H, Peirovi R, Ghasemi A, Zarei A. Assessment of human health risks and pollution index for heavy metals in farmlands irrigated by effluents of stabilization ponds. *Environ Sci Pollut Res*. 2020;27(10):10317-10327.
4. Mahurpawar M. Effects of heavy metals on human health. *Int J Res Granthaalayah*. 2015;530(516):1-7
5. Saidon NB, Szabó R, Budai P, Lehel J. Trophic transfer and biomagnification potential of environmental contaminants (heavy metals) in aquatic ecosystems. *Environ Pollut*. 2024; 340:122815.
6. Neisi A, Farhadi M, Cheraghian B, Dargahi A, Ahmadi M, Takdastan A, et al. Consumption of foods contaminated with heavy metals and their association with cardiovascular disease (CVD) using GAM software (cohort study). *Heliyon*. 2024;10(2).
7. Ohiagu FO, Chikezie PC, Ahaneku CC, Chikezie CM. Human exposure to heavy metals: toxicity mechanisms and health implications. *Mater Sci Eng Int J*. 2022;6(2):78-87.
8. Massadeh AM, Al-Massaedh AAT. Determination of heavy metals in canned fruits and vegetables sold in Jordan market. *Environ Sci Pollut Res*. 2018;25(2):1914-1920.
9. Ajayi AT, Njoku KL. Concentration and Human Health Risk Assessment of Alkylphenols, Bisphenols and Some Heavy Metals in Selected Canned Foods in Lagos, Nigeria. *J Appl Sci Environ Manag*. 2023;27(3):531.
10. Ojezele OJ, Okparaocha FJ, Oyeleke PO, Agboola HI. Quantification of some metals in commonly consumed canned foods in south-west Nigeria: probable pointer to metal toxicity. *J Appl Sci Environ Manag*. 2021;25(8).
11. Ebrahimi M, Khalili N, Razi S, Keshavarz-Fathi M, Khalili N, Rezaei N. Effects of lead and cadmium on the immune system and cancer progression. *J Environ Health Sci Eng*. 2020;18(1):335-343.
12. Sharma P, Dubey RS. Lead toxicity in plants. *Braz J Plant Physiol*. 2005;17(1):35-52.
13. Angon PB, Islam MS, Das A, Anjum N, Poudel A, Suchi SA. Sources, effects and present perspectives of heavy metals contamination: Soil, plants and human food chain. *Heliyon*. 2024;10(7).
14. Munir N, Jahangeer M, Bouyahya A, El Omari N, Ghchime R, Balahbib A, et al. Heavy metal contamination of natural foods is a serious health issue: A review. *Sustainability*. 2021;14(1):161.
15. Al Zabadi H, Sayeh G, Jodeh S. Environmental exposure assessment of cadmium, lead, copper and zinc in different Palestinian canned foods. *Agric Food Secur*. 2018;7(1):50.
16. Nathaniel B, John M, Sylvester T, Mercy B, Irene O. Levels of selected heavy metals in canned tomato paste sold in Ghana. *Food Addit Contam Part B*. 2012;1-5. doi:10.1080/19393210.2012.657250.
17. Shavali Gilani P, Esmaeili Z, Khosravani M, Motamedi M, Maleknejad S, Adabi M, et al. Nanotechnology-driven EGCG: bridging antioxidant and therapeutic roles in metabolic and cancer pathways. *Nanomedicine*. 2025;20(6):621-636.