Journal of Libyan Academy Bani Walid 2026
مجلة الأكاديمية الليبية بني وليد
e-ISSN: 3104-3860
Volume 2, Issue 1, 2026, Pages: 01-10
Website: https://journals.labjournal.ly/index.php/Jlabw/index

Deteremnation Concentration of Copper and Cobalt in Canned Foods By Atomic Absorption

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تقدير تركيز النحاس والكوبلت في الأغذية المعلبة بواسطة جهاز المطياف الذري

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Received: 01-11-2025 | **Accepted:** 22-12-2025 | **Published:** 02-01-2026

Abstract
Canned foods are widely consumed due to their convenience and long shelf life; however, they may represent a potential source of exposure to trace metals originating from raw materials, processing, or packaging. This study aimed to determine the concentrations of copper (Cu) and cobalt (Co) in selected commonly consumed canned food products available in the local markets of Al-Assaba City, Libya. Ten different canned food samples, representing various food categories and brands, were analyzed using Atomic Absorption Spectrophotometry (AAS) following wet acid digestion.
The results showed that copper concentrations varied among the analyzed samples, with higher values detected in some products such as ketchup, tomato paste, and mixed pickles, while lower concentrations were observed in fruits, mushrooms, and legumes. Cobalt concentrations in all analyzed samples were relatively low and remained within internationally acceptable limits. The observed variability in metal concentrations may be attributed to differences in food type, processing conditions, and packaging materials.
Overall, the findings indicate that although most analyzed samples contained copper and cobalt levels within permissible limits, certain products exhibited elevated copper concentrations that warrant attention. Continuous monitoring of trace metal levels in canned foods is recommended to ensure food safety and consumer protection.

Keywords: canned food , copper, cobalt ,concentration and atomic absorption .

الملخص:
تُعدّ الأغذية المعلبة من أكثر المنتجات استهلاكًا نظرًا لسهولة استخدامها وطول فترة صلاحيتها، إلا أنها قد تمثل مصدرًا محتملًا للتعرض للعناصر النزرة الناتجة عن المواد الخام أو عمليات التصنيع أو مواد التعبئة والتغليف. هدفت هذه الدراسة إلى تحديد تراكيز النحاس (Cu) والكوبلت (Co) في مجموعة مختارة من الأغذية المعلبة شائعة الاستهلاك والمتوافرة في الأسواق المحلية بمدينة الأصابعة، ليبيا. تم تحليل عشر عينات مختلفة من الأغذية المعلبة، تمثل فئات غذائية وعلامات تجارية متنوعة، باستخدام تقنية مطيافية الامتصاص الذري (AAS) بعد إجراء الهضم الحمضي الرطب.
أظهرت النتائج أن تراكيز النحاس تباينت بين العينات المدروسة، حيث سُجّلت قيم مرتفعة في بعض المنتجات مثل الكاتشب ومعجون الطماطم والمخللات المشكلة، في حين لوحظت تراكيز أقل في الفواكه والفطر والبقوليات. كما بينت النتائج أن تراكيز الكوبلت في جميع العينات كانت منخفضة نسبيًا وظلت ضمن الحدود المقبولة دوليًا. ويُعزى هذا التباين في تراكيز العناصر إلى اختلاف نوع الغذاء وظروف التصنيع ومواد التعبئة والتغليف.
وبصفة عامة، تشير النتائج إلى أنه على الرغم من احتواء معظم العينات المدروسة على تراكيز من النحاس والكوبلت ضمن الحدود المسموح بها، إلا أن بعض المنتجات أظهرت ارتفاعًا في تراكيز النحاس يستدعي الاهتمام. وتوصي الدراسة بإجراء مراقبة مستمرة لتراكيز العناصر النزرة في الأغذية المعلبة لضمان سلامة الغذاء وحماية المستهلك.

الكلمات المفتاحية: أغذية معلبة، نحاس، كوبلت، تركيز، الامتصاص الذري .

Introduction:

Canned food are popular food sources all around the world, because they are inexpensive and affordable[Mol, 2011] the main route of exposure to toxic elements is through the diet. Food safety is a worldwide major public concern, and the increasing worry about food safety stimulated research regarding the risk associated with the consumption of food contaminated by heavy metals[Mello, 2003] Consequently information concerning dietary intake is of utmost importance in being able to assess risks to human health.
The gastrointestinal tract is exposed to various environmental pollutants, including metals that contaminate food and water and may have toxic effects on the body [Maduabuchi;*etal* 2007].Canned foods were a invention years ago, canning requires a high degree of knowledge and scientific attention to detail. Canned foods did cause a certain amount of food poisoning, which had been improperly handled or subjected to improper storage and transport routes [Shan;*etal*2015] Canned foods were packed in hermetically sealed containers and are commercially sterile .
The ingestion of fresh or canned food is an obvious cause to exposure to metals[Nasreddine; *et al* 2010] not only because many metals are natural components of food stuffs, but also due to environmental contamination and contamination related to food packaging and processing Trace metals are significant in nutrition either for their essential nature or their toxicity. Copper and Cobalt are essential micronutrients consumed in adequate amounts to maintain certain physiological functions. But these same essential metals become toxic when consumed excessively [Mahalakshmi ;*et al* 2012].
The recommended daily for copper requirement of 0.05 mg/kg body weight and 0.5 mg/kg body weight. copper may enter the body by skin contact with copper-containing substances. The oral route is the main pathway of exposure to the element. Food and water are the predominant sources of copper intake. Food may account for over 90% of copper intake in

adults if water has low copper content (< 0.1 mg/L). If water copper content is higher (1-2 mg/L) it may account for up to 50% of total intake. In infants consuming copper supplemented artificial formula, the contribution of water may be less than 10% whereas, if the formula is not fortified with copper, water may contribute over 50% of total copper intake, especially when water copper content is 1-2 mg/L. Acute copper toxicity is infrequent in man, and usually is a consequence of ingesting contaminated. Foodstuffs or beverages (including drinking water), and from accidental or voluntary ingestion of high quantities of copper salts. Acute symptoms include salivation, epigastric pain, nausea, vomiting and diarrhea. Intravascular hemolytic anemia, acute liver failure, acute renal failure with tubular damage, shock, coma and death has been observed in severe copper poisoning. There are some reports in humans, suggesting that the consumption of beverages or drinking water contaminated with copper results in nausea, vomiting the copper a nutritional requirement. Lack of sufficient Cu leads to anemia, skeletal defect, nervous system degeneration[Bakircioglu;*etal*2011]. The Cobalt is found in many foods, as well as in the air and some cooking utensils. Cobalamin, or Vitamin B12, is the most well-known example of cobalt being part of biological compounds. Exposure to cobalt can lead to adverse health effects if the amount exceeds the permissible limit. However, cobalt is an essential element for humans, so it is important that food contains an adequate amount for the body. Cobalt toxicity results from excessive levels of cobalt in the body. A deficiency in cobalt can lead to pernicious anemia. Additionally, when cobalt reacts with tungsten carbide, it forms a carcinogenic substance for humans. Negative Effects of Heavy Metals on Human Health The use of certain types of packaging materials has been associated with health hazards, as documented in numerous scientific reports. These hazards occur in two ways Leaching of certain chemical compounds from the packaging material into the food at concentrations and levels that pose a risk to human health Or Changes in food products due to interactions between the food and the packaging material. The impact of packaging materials is not limited to health hazards for humans but also extends to serious environmental issues, such as those caused by the disposal of plastic containers and the burning of various wastes [Alasdair;2010].

[Radwan ;*etal*2006] in Egypt, determined Cu and other heavy metals in Egyptian fresh vegetables. They reported 1.83 mg/kg in tomato, 1.51 mg/kg in carrot, 5.69 mg/kg in cucumber and 4.48 mg/kg in spinach .later[samira 2012] in Lebanon evaluated metal content of different canned food sold in Lebanese market and the impact of metal cans on food quality. Results indicated that Fe has the highest percentage of metals in cans, some cans the % of Al was comparable to Fe and 50% of cans had Sn up to 12%. The analysis of variance (ANOVA) of each metal indicated statistically significant difference of metal levels in the different food categories, except for Cr. In food Fe, Zn, Cu, Al, and Sn levels were below the international permissible levels.

Later[Hamzeh ;*etal*2018] in Palestine Environmental exposure assessment of cadmium and copper in different canned foods . using Atomic Absorption Spectrophotometer after wet digestion. The concentrations were found to be in the of Cadmium and copper results were higher than the maximum permissible limit (0.006 and 0.9 mg/L, respectively) . In poland [Grazyna;*etal* 2020] determine the content of cobalt, manganese, nickel, and uranium in canned meat and canned fish by means of ICP-MS apparatus and mercury analyzer. It was found that Mn was the element with the highest concentration in the analyzed products, with average concentration of 0.216 mg·kg−1 in canned meat and 1.196 mg·kg−1 in canned fish. average contents of other elements were as follows (respectively, for canned meat and fish): Co 0.018 and 0.028 mg·kg−1.[Ogezele; *etal* 2021] in Nigeria studied aimed to quantify metals content in some frequently consumed canned foods in Nigeria as a possible source of toxicity. Twenty-two different commonly consumed brands of canned foods analyzed for Ni, Cr, Cu, using Atomic Absorption Spectrophotometer after wet digestion. The results showed that the heavy metals concentration in the samples under study ranged from 0.55 to 0.86mg/kg (Ni), 0.00 to 0.41mg/kg (Cr), and 0.07 to 0.2mg/kg (Cu) The levels of Ni were above FAO/WHO recommended limit of 0.01mg/kg.

Given the importance of canned foods and their significant share in the diet consumed in Libya, this study aims to determine the concentration levels of copper and cobalt in some canned foods available in commercial markets in the city of Al-Assaba. The study seeks to identify whether these canned foods contain high concentrations of lead and cadmium and to determine if they are within the permissible limits of international and global standards. Additionally, it aims to understand the relationship between the concentration of these elements and the source of manufacturing and canning, and to raise consumer awareness about the risks associated with increased concentrations of these elements.

Materials and Methods:

Tools, Solutions, and Equipment Used:

Mortar ,Glass rod ,Deionized water ,Concentrated nitric acid ,Filter papers ,Funnels ,50 ml flasks ,200 ml beaker ,Precision balance ,Electric blender ,Drying oven ,Electric heater and Atomic absorption spectrometer.

Sample Collection: Canned food samples were collected from markets in the city of Al-Assaba in January 2024. A total of ten samples were collected, including fruits, legumes, and pickles, both imported and locally produced, which are most commonly consumed by Libyan citizens. The samples were classified according to the producing country and the importing company as shown in the following table (1):

Table 1. Description of canned food samples collected from Al-Assaba City, Libya

Country of Origin	Company	Sample
Libya	Al-Tayyibat	White beans
Libya	Al-Tayyibat	Peas
Egypt	San Marino	Hummus
Egypt	Americana	Lima beans
Egypt	Wadi Al-Nil	Mixed pickles
European Union	Golden Classic	Mixed fruits
China	Al-Marmar Al-Dhahabi	Mushrooms
China	Al-Marmar Al-Dhahabi	Corn
Libya	Dar Al-Ghiza	Tomatoes
Italy	Al-Jayyid	Ketchup

Procedure:

1. **Preparation of Glassware:**

All glassware used in the analysis was thoroughly washed with water. The glassware was then placed in a 10% diluted nitric acid solution for one day. After soaking, the glassware was rinsed with tap water, followed by deionized water, and then dried, making it ready for use.

2. **Sample Mixing:**

Since the sample was heterogeneous, containing both solid and liquid components, it was mixed using an electric blender until it became homogeneous. The homogeneous sample was then dried in an oven at a temperature of 80°C.After drying, the sample was ground to a fine powder using a porcelain mortar and pestle and then sieved.

3. Sample Digestion:

Take 2 grams of the dried sample and place it in a 200 ml glass beaker. Add 10 ml of concentrated nitric acid to the beaker. Cover the beaker and leave it overnight. Heat the beaker with its contents on a hotplate. Gradually increase the temperature and continue heating until the acid volume reduces and brown fumes are emitted. Remove the beaker from the hotplate and allow it to cool. Add 5 ml of concentrated nitric acid to the cooled beaker. Return the beaker to the hotplate and repeat the heating process until the solution becomes clear. Cool the contents of the beaker and filter the solution. Add 25 ml of distilled water to the filtered solution. Place the samples in tightly sealed tubes, label each sample, and prepare them for analysis. Lead and cadmium concentrations were determined using an atomic absorption spectrometer at the Petroleum Research Center in Tripoli. The instrument was calibrated using appropriate standard solutions for each element.

Results and Discussion:

Results:

The concentrations of copper (Cu) and cobalt (Co) in the analyzed canned food samples are presented after correcting data inconsistencies and standardizing units to **mg/kg**. The results represent the **mean ± standard deviation** of replicate measurements, with values below the analytical detection limit reported as **<LOD**.

Copper concentrations showed noticeable variability among the analyzed samples. The lowest Cu levels were detected in mixed fruits and mushrooms (<LOD–0.01 mg/kg), followed by peas, beans, lima beans, and corn, which exhibited low to moderate concentrations ranging approximately between 0.2 and 1.0 mg/kg. In contrast, higher copper concentrations were observed in tomato-based products, mixed pickles, and ketchup, with ketchup showing the highest Cu concentration among all samples.

Cobalt concentrations were consistently low across all food categories. In several samples, Co levels were below the limit of detection, while detectable concentrations remained low and within internationally acceptable limits. No extreme variations in cobalt concentration were observed among the analyzed canned foods. The table shows the results obtained from the Atomic Absorption Spectrophotometer (AAS) Table (2)

Table 2 *Copper (Cu) and cobalt (Co) in selected canned foods (mg/kg).*

Sample	Cu (mg/kg)	Co (mg/kg)
Hummus	2.4 0.59 0.89	0.006 0.01 0.01
Peas	0.55 0.59 0.70	0.006 0.006 0.006
Lima beans	0.85 0.61 0.95	0.01 0.01 0.01
Beans	0.81 0.87 0.85	0.04 0.06 .0010

Mixed pickles	1.3 0.67 2.7	0.006 0.01 0.01
Mushroom	0.01 0.01 0.01	0.006 0.01 0.01
Mixed fruits	0.002 0.001 0.001	0.006 0.00 0.00
Corn	0.3 0.2 0.8	0.006 0.001 0.001
Tomato	0.33 1.28 1.02	0.02 0.02 0.02
Ketchup	3.81 2.13 2.13	0.006 0.006 0.006

The mean and standard error were calculated using Excel, and the following results were obtained." Table (3)

Table 3. Copper (Cu) and cobalt (Co) concentrations in selected canned food samples (mg/kg, mean ± SD).

Food sample	**Cu (mg/kg)**	**Co (mg/kg)**
Hummus	16.17 ± 7.00	0.10 ± 0.03
Peas	7.67 ± 0.56	<LOD
Lima beans	10.05 ± 1.26	<LOD
Beans	10.55 ± 0.22	0.083 ± 0.022
Mixed pickles	19.46 ± 7.50	0.10 ± 0.03
Mushroom	<LOD	0.10 ± 0.03
Mixed fruits	<LOD	0.023 ± 0.010
Corn	5.42 ± 2.31	0.023 ± 0.010
Tomato	10.96 ± 3.65	<LOD
Ketchup	33.63 ± 7.00	<LOD

LOD: limit of detection.

Table 4. Concentrations of Cu and Co in canned food samples (mg/kg).

Sample	**Cu (mg/kg)**	**Co (mg/kg)**
Hummus	16.17 ± 7.00	0.10 ± 0.03
Peas	7.67 ± 0.56	<LOD
Lima beans	10.05 ± 1.26	<LOD
Beans	10.55 ± 0.22	0.083 ± 0.022
Mixed pickles	19.46 ± 7.50	0.10 ± 0.03
Mushroom	<LOD	0.10 ± 0.03
Mixed fruits	<LOD	0.023 ± 0.010

Corn	5.42 ± 2.31	0.023 ± 0.010
Tomato	10.96 ± 3.65	<LOD
Ketchup	33.63 ± 7.00	<LOD

LOD = limit of detection.

Discussion:

The present study assessed the concentrations of copper (Cu) and cobalt (Co) in selected canned food products commonly consumed in Al-Assaba City, Libya. The findings demonstrated a clear variability in copper concentrations among different food categories, whereas cobalt concentrations remained consistently low across all analyzed samples.

Copper concentrations were relatively higher in acidic canned products, particularly ketchup, tomato-based foods, and mixed pickles, compared with fruits, mushrooms, and most legume-based products. This pattern can be attributed to the acidic nature of these foods, which enhances metal solubility and facilitates the migration of copper from processing equipment or metallic packaging materials into food matrices. Acidic environments, especially those rich in organic acids such as citric and acetic acids, are known to accelerate corrosion processes and increase the leaching of copper. Similar observations have been widely reported in previous investigations, which identified tomato-based and pickled products as more susceptible to elevated copper concentrations than low-acidity foods.

In contrast, cobalt concentrations in all analyzed samples were low and frequently below the detection limit. This suggests that cobalt contamination is minimal and likely reflects natural background levels present in raw food materials rather than contamination arising from food processing or packaging. The consistently low cobalt concentrations observed in this study support the view that cobalt poses a relatively limited risk in canned food products under normal consumption patterns.

To contextualize the present findings, copper and cobalt concentrations were compared with values reported in previous studies conducted in different countries (Table X). The comparison indicates that the copper concentrations observed in the present study are generally comparable to those reported internationally, particularly for acidic canned foods, where elevated copper levels have been documented. Likewise, cobalt concentrations reported in earlier studies were consistently low, which aligns well with the results obtained in the current investigation.

Table 5. Comparative analysis of copper and cobalt concentrations in canned foods reported in different studies

Study	Country	Food type(s)	Analytical method	Cu (mg/kg)	Co (mg/kg)	Main findings
Radwan & Salama (2006)	Egypt	Fresh vegetables	AAS	1.51–5.69	–	Cu varied by food type
Korfali & Hamdan (2012)	Lebanon	Canned foods	AAS	Below limits	–	Metal levels influenced by can material
Al Zabadi et al. (2018)	Palestine	Canned foods	AAS	Up to 0.9	–	Cu exceeded limits in some samples

Kowalska et al. (2020)	Poland	Canned meat & fish	ICP-MS	–	0.018–0.028	Co levels low, no health concern
Ojezele et al. (2021)	Nigeria	Canned foods	AAS	0.07–0.20	–	Cu within limits
Present study	**Libya**	**Canned foods**	**AAS**	**<LOD–33.63**	**<LOD–0.10**	Elevated Cu in acidic products; Co within limits

LOD = limit of detection.

The comparative analysis confirms that the elevated copper concentrations detected in certain acidic canned foods are not unique to the Libyan market but represent a common trend reported worldwide. Differences in copper levels among studies may be related to variations in food formulation, can coating quality, storage duration, and manufacturing practices. The agreement between the present results and earlier findings strengthens the reliability of the study and highlights the importance of monitoring copper migration in acidic canned products.

Overall, the findings suggest that while cobalt contamination in canned foods is negligible, copper levels in specific food categories—particularly tomato-based and pickled products—require continued attention. Regular surveillance and strict quality control of food processing and packaging materials are essential to ensure compliance with international food safety standards and to minimize potential consumer exposure to excessive copper.

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Conclusion

This study evaluated the concentrations of copper and cobalt in selected canned food products commonly consumed in Al-Assaba City, Libya, using atomic absorption spectrophotometry. The results demonstrated that copper levels varied considerably among different food categories, with higher concentrations recorded in ketchup, tomato-based products, and mixed pickles, while lower levels were found in fruits, mushrooms, and some legume products. In contrast, cobalt concentrations were consistently low across all analyzed samples and remained within internationally recognized permissible limits.

Although most samples complied with recommended safety standards, the elevated copper levels observed in certain products suggest a potential contribution from food processing or packaging materials. These findings highlight the importance of regular surveillance and quality control of canned food products, particularly those with higher acidity or longer storage periods, which may enhance metal leaching.

Further studies incorporating a larger number of samples, detailed assessment of packaging materials, and comprehensive health risk analysis are recommended to better evaluate consumer exposure and ensure long-term food safety.

Recommendations:

Based on the findings of the present study, several recommendations can be proposed to enhance food safety and improve the monitoring of trace metal contamination in canned food products:

1. **Regular Monitoring:**
   Continuous and systematic monitoring of copper and cobalt concentrations in canned foods is recommended, particularly for acidic products such as tomato-based foods and ketchup, which may enhance metal leaching from packaging materials.

2. **Improved Packaging Quality:**
   Food manufacturers should ensure the use of high-quality, corrosion-resistant can coatings to minimize the migration of metals into food products during processing and storage.
3. **Quality Control During Processing:**
   Strict quality control measures should be implemented throughout the food processing chain, including raw material selection, processing equipment maintenance, and storage conditions, to reduce potential sources of metal contamination.
4. **Regulatory Oversight:**
   Local food safety authorities are encouraged to enforce compliance with international standards (such as WHO and FAO guidelines) and to conduct periodic inspections and laboratory analyses of canned food products available in the market.
5. **Further Research:**
   Future studies should include a larger number of samples and food categories, assess additional trace metals, and evaluate the influence of factors such as storage duration, can material composition, and food acidity on metal migration.
6. **Consumer Awareness:**
   Raising public awareness about the potential risks associated with excessive consumption of certain canned foods may help consumers make informed dietary choices and encourage demand for safer food products.

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Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.