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Determination of some Microbial Contaminants and Heavy Metal in Some Types of Imported Canned Meat

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ABSTRACT

This study aimed to detect microbial contaminants and heavy metal elements potentially present in some types of imported canned meat. The study involved collecting 12 brands of canned meat (luncheon and hot dog), produced from beef and chicken. Standard microbiological methods were used for the isolation and identification of bacteria. The results showed that some brands were contaminated with some types of bacteria, namely Clostridium spp. and Streptococcus spp., and Staphylococcus aureus. This is a key finding but is not clearly supported by the data in Table 3, and the highest contamination rate was with Staphylococcus, followed by Streptococcus and finally Clostridium bacteria. The concentrations of selected heavy metals in canned meat were determined using atomic absorption spectrometry. Lead concentration was highest in brand BH1 at 4.235 ppm and the highest concentration of Sn was 2.904 ppm in BH2 brand. In general, both Zn and Fe concentrations were high in all brands and the highest reached 24.082 ppm and 387.083 ppm in (C1 and B1) brands respectively. Aluminum (Al) concentrations were low in all brands and the highest concentration reached 0.662 ppm in C3 brand.

1-INTRODUCTION

Ensuring food safety and security are critical objectives, representing some of the most pressing issues facing the world today. Consequently, advancements and innovations in food packaging technology should be utilized in this area. Food production has been a major challenge, especially in the wake of the recent international trade growth, in that, striving to meet the growing demands of food globally and remain safe throughout the processing, and packaging of food, so that consumers can access the food fresh, healthy, and uncontaminated [1]. Meat is known as an excellent protein source, and lipids, vitamins, and minerals [2]. Canning of meat is a conventional process that occurred as a consequence of the need to protect the shelf life of consumable food products. First, salt was very essential in preserving meat. Some types of salt are good to give the meat a nice reddish-pink hue. The global demographic landscape started to shift in the mid-nineteenth century, driven by advancements in food production, particularly in meat and its derivatives, alongside a growing demand for reliable food sources and commercial preservation techniques [3,4]. The contamination of red meat and poultry by Salmonella Typhi and Staphylococcus aureus bacteria presents a considerable food safety hazard [4]. Improperly processed or damaged canned foods can provide a suitable environment for the growth of pathogenic bacteria, such as Clostridium botulinum, and the production of their toxins. Botulinum toxin for example, is considered one of the most dangerous types of toxins because it disrupts the central nervous system and may cause death as a result of paralysis of the respiratory muscles. Canned meat products are widely consumed globally due to their convenience and long shelf-life. They are particularly attractive to working families, fast food restaurants, and cafeterias, and others, because of their constant presence and low costs [5]. It is available and easy to cook and use when carrying out various activities such as camping and other circumstances, such as natural disasters, when conventional ways of preserving food, such as refrigerators or freezers, are not accessible The basic primary ingredients are beef or poultry meat, which is served in various forms like minced or chopped meat, which is often accompanied by other ingredients like spices, soy protein, starch, nitrites, salt, ascorbate, and phosphates Mohd Abdullah, 2007 [6] Zangana and Al-Sham (2016) [7] Mining, smelting, battery production, tanning, and petroleum refining are some of the human activities that have resulted in the deposition of toxic elements and heavy metal in water sources and wastes [8]. The presence of toxic metal elements in food items whether in low level is a major hazard to the human and the ecosystem [9], due to the challenges associated with their breakdown in the human body or the environment. This can be ascribed to their inherent biological characteristics that facilitate their accumulation in diverse tissues within both human and animal bodies [10].

2- Materials and Methods

Chemicals

All chemicals and culture media were of analytical grade and purchased commercially included sterile petri dishes, nutrient media (nutrient broth, and nutrient agar), diagnostic media including (Blood agar, MacConkey agar, XLD agar, Mantol salt agar, and HI carom agar), sterile pipettes, water bath, HNO_3, HCl acids supplied by (Sigma-Aldrich) and other laboratory materials.

Brands Collection

A total of 12 brands of low acidity imported canned meat including (3) brands of beef luncheon, 3 beef hotdog brands, 3 brands of chicken meat luncheon, and 3 brands of chicken hot dog) were randomly purchased from different shops and markets in Baghdad during the period from October 2023 to January 2024. The imported canned

meat brands were stored in the room at a temperature of 25±5°C. For each brand examined, a comprehensive set of tests for microbial and mineral elements was performed, as detailed in table (1). The imported canned meat brands were kept in the room at a temperature of 25±5°C. For each brand under study, a series of microbial and mineral elements tests were conducted as shown in table (1).

Table 1. Canned meat imported brands used in the study

No.	Brands	Code ID	Country of origin	Product validity	
				Production date	Expiry date
1	Beef meat Luncheon	B1	Lebanon	20/07/2023	19/07/2025
2	Beef meat Luncheon	B2	Saudi Arabia	04/10/2023	02/10/2025
3	Beef meat Luncheon	B3	Türkiye	20/01/2023	19/01/2025
4	Beef meat hot dog	BH1	Jordan	01/11/2023	31/10/2025
5	Beef meat hot dog	BH2	Saudi Arabia	10/08/2023	09/02/2025
6	Beef meat hot dog	BH3	Türkiye	24/12/2023	23/12/2025
7	Chicken meat luncheon	C1	Lebanon	20/07/2023	19/07/2025
8	Chicken meat luncheon	C2	Saudi Arabia	04/10/2023	02/10/2025
9	Chicken meat luncheon	C3	Türkiye	20/01/2023	19/01/2025
10	Chicken meat hot dog	CH1	Jordan	01/11/2023	31/10/2025
11	Chicken meat hot dog	CH2	Saudi Arabia	10/08/2023	09/02/2025
12	Chicken meat hot dog	CH3	Türkiye	24/12/2023	23/12/2025

Total Plate Count

Prior to analysis, the external surface of each canned meat container was disinfected with 70% ethanol. The can opener was flame-sterilized using a Bunsen burner before use. For each brand, the can was opened aseptically, and a 5 g aliquot of the contents was accurately weighed and transferred to a sterile stomacher bag. The sample was homogenized with 45 mL of sterile Buffered Peptone Water (BPW) using a stomacher (or blender) for 2 minutes to create a 1:10 initial dilution (Fig. 1).

Subsequent serial decimal dilutions (10^{-1} to 10^{-6}) were prepared in sterile 0.85% physiological saline. From appropriate dilutions, 1 mL aliquots were transferred in duplicate into sterile Petri dishes. Approximately 15–20 mL of melted Plate Count Agar (PCA), cooled to 45°C, was poured into each plate. The agar was gently swirled for even distribution and allowed to solidify. The plates were then incubated aerobically at 37°C for 24–48 hours.

Colonies on plates containing 30–300 colonies were counted. The total aerobic mesophilic count was calculated using the following formula and expressed as colony-forming units per gram (CFU/g):

CFU/g = (Number of colonies × Dilution Factor) / Volume plated (mL)

For the spread plate method (used in parallel), 0.1 mL of each dilution was spread onto the surface of pre-poured and dried PCA plates. The calculation factor was adjusted accordingly [11].

Fig (1). preparing the samples to estimate total plate count in the brands meat caned

Isolation and Preliminary Identification of Presumptive Pathogenic Bacteria

Following the initial homogenization in BPW (Section 2.1), the mixture was incubated at 37°C for 18–24 hours for pre-enrichment. A loopful from the enriched broth was then streaked onto selective and differential agar media, including Blood Agar (BA), Mannitol Salt Agar (MSA), and MacConkey Agar (MCA). All plates were incubated aerobically at 37°C for 24–48 hours.

Distinct colonies with morphologies suggestive of *Staphylococcus* spp., *Streptococcus* spp. , and Gram-negative enteric bacteria were selected and sub-cultured on BA to obtain pure isolates. Pure cultures were subjected to Gram staining according to standard protocol [13]. Briefly, heat-fixed smears were stained with crystal violet, treated with Gram's iodine, decolorized with ethanol, and counterstained with safranin. Cellular morphology and Gram reaction (purple for Gram-positive; red/pink for Gram-negative) were observed under an oil-immersion microscope (1000x magnification).

Biochemical Characterization of Bacterial Isolates

Gram-positive, catalase-positive cocci clusters were presumptively identified as *Staphylococcus* spp. and tested for coagulase production using rabbit plasma. Catalase-negative, Gram-positive cocci (in chains or pairs) were subjected to hemolysis patterns on BA and CAMP test for preliminary identification of *Streptococcus*/*Enterococcus* spp.

Gram-negative isolates were initially characterized based on lactose fermentation on MCA and subjected to a series of biochemical tests using triple sugar iron (TSI) agar, Simmons citrate agar, urea agar, and sulfide-indole-motility (SIM) medium. Standard biochemical test protocols were followed for oxidase, catalase, indole, methyl red, Voges-Proskauer, and citrate utilization (IMViC tests) [12, 14].

Final identification was based on a combination of colonial morphology, Gram stain characteristics, and a comprehensive biochemical profile, compared to standard references [12, 14].

Oxidase Test

Oxidase Test is used to determine microorganisms that have cytochrome oxidase which is an enzyme that is involved in the electron transport chain. The test is used to differentiate between the oxidase

positive and negative intestinal bacteria. Oxidase reagent, N'-Tetramethyl-p-phenylenediamine dihydrochloride (TMPD) is added in a few drops onto a piece of filter paper after which a colony of the organism under study is placed on to the filter paper, which has been covered with the oxidase reagent. The principle of the test is based on the fact that p-Phenylenediamine (PPD) is introduced in the reagent that is oxidized because of the presence of bacteria that synthesize the oxidase enzyme. In turn, a dark purple hue of p-Phenylenediamine will appear several seconds due to this oxidation and this means that there are bacteria that produce the oxidase enzyme.

Sugar Fermentation Test

The ability of bacteria to ferment carbohydrates varies among bacteria strains with some having the ability to ferment certain carbohydrates. Fermentation test is done to determine the fermentation capability of bacteria in specific carbohydrates and to distinguish the bacterial types. The testing is done by recognizing acids or gases produced during the secondary fermentation process of carbohydrates, using a food medium as a carbohydrate source. Moreover, the pH value of the culture medium is identified as an indicator of (bromothymol blue (BTB)) which is a shift in the value of the medium when the medium became less acidic as the acid was produced by means of fermentation. Durham tubes are small inverted tubes that are used to test the presence of hydrogen or carbon dioxide gas by immersion in a culture medium. The outcome of this test is always positive on all the members of the family Enterobacteraceae.

Catalase Test

This test is used to determine the presence of organisms which display the catalase enzyme production. The enzyme is good in reacting with hydrogen peroxide (H_2O_2) which is defined by the capacity to release oxygen in hydrogen peroxide by breaking it down to water and oxygen gas. This role, therefore, enables the test to identify the existence of this enzyme. A sterile slide was used to add a drop of 3% hydrogen peroxide solution to a loop of the organism. The presence of foam or bubbling is a positive result.

Indole Test

The test is used to determine the members of the Enterobacteriaceae family and other pathogenic bacteria by basing on the ability of organisms to produce indole through the breakdown of tryptophan. The process entails harvesting the brands of the cultured bacteria, which have been incubated at an appropriate period of time of 18-24 hours, and then inoculated into tryptophan tubes. The broths of tryptophan are incubated at 37 deg C in the presence of 0.5 ml of Kovacs reagent. The formation or absence of a red-colored ring when tested in the surface of the broth is a clear sign that will give us a positive or negative test result.

Citrate test

The test is used to determine the ability of bacteria to use sodium citrate as the sole carbon source. The reagent in this medium is Bromothymol blue. Under the positive circumstance, the compound (NH4)2 OH is produced, which causes a basic medium, and therefore, changes the medium to blue color. This is done by preparing a medium at an angled position after which a young bacterial colony is swabbed. The culture of this brand is then transferred to Simmons

Citrate agar (SCA) and allowed to incubate in 48 hours at 37degC. The fact that the indicator (Bromothymol blue) changed to blue when the medium became alkaline, is evidence that the test produces a positive result.

Coagulase test

The objective is to have a differentiation between Staphylococcus aureus which reacts positively to enzyme Coagulase and the numerous other forms of the enzyme Coagulase produced by Staphylococci S. aureus. Bound coagulase is associated with free coagulase which is an extracellular digestive enzyme that causes clotting on the treatment of S. aureus colonies with plasma. The process includes the application of a drop of coagulated plasma on a clean and dry glass slide. A droplet of distilled water is placed at certain distance of the plasma drop to act as a control. The separated bacteria are then inoculated to each drop by a sterile metal loop. The result is evaluated using the fact that at the end of 10 seconds, there would be or there would not be any clotting size on the brand or the control.

Urease test

This test is used to determine the ability of bacteria to produce urease enzyme, which breaks down urea. The decarboxylation of the amino acids produces urea whereas the hydrolysis of urea produces carbon dioxide and ammonia. Bacteria with rapid positivity to the urease test like (Proteus spp. and Morganella morganii) make the medium turn pink in a couple of hours whereas, bacteria with weak positivity like (Klebsiella spp. and Enterobacter species) may take days to show. The negative bacteria like (Escherichia coli) do not produce any color or get a yellow color because of the production of acid. The process includes the dissolution of 1 g of enzymatic digested gelatin, 1 g of dextrose, 5g of sodium chloride (NaCl), 2g of potassium dihydrogen phosphate (KH2PO4), 20 g of urea, and 0.012 g of phenol red in a given amount of distilled water. The pH is regulated to 6.8 and the total volume is raised to 1000 ml. This solution is then sterilized in an autoclave at 121degC and 15minutes after which it is dispersed in sterile tubes. A portion of a pure isolated colony is inoculated on the inclined surface of the urea and incubated at the temperature range of (35-37) degC under aerobic conditions over a period of (48) hours to (7) days with the tube cap being left open (not tightly closed in place).

Gelatin hydrolysis test

The test is a diagnostic method used to determine the type of bacteria present, e.g. Staphylococcus spp., Enterobacteriaceae and some G + ve rods. This test is used to analyze the ability of bacteria to produce extracellular proteolytic enzymes. The test procedure entails preparations of a culture medium by dissolving enzymatic digest of gelatin of 5 g, 3g of beef extract and 120g of gelatin in the distilled water, then the pH is adjusted to 6.8 and 1000 ml of distilled water is added. The mixture is then sterilized using autoclave at 121degC during 15 minutes. The media is next spread out into tubes, and subsequently sterilized. Inoculation is done in gelatin tubes with 4-5 drops of 24-hour old liquid culture and incubation of the liquid culture under aerobic conditions is carried out at (35-37) degC previously up to a period of 14 days. After incubation, the gelatin tubes are subjected to the liquefaction test at 4degC, to make sure that the tube is not

turned. Inoculated tubes are cooled on the side of the control tubes which remain uninoculated. The assessment of liquefaction is done only after the gelatin in the control tubes hardens. In case of partial or total liquefaction (complete solidification of control pipes is a requirement) at the temperature of 4degC during 14 days, the outcome is positive. On the other hand, the outcome is not favorable when the medium totally solidifies at 4degC temperature.

Blood agar or coagulation test

Bacteria are variable in their growth needs especially when it comes to the nutrients which are required to develop them. This is due to the stimulated growth of bacteria when they are inculcated in a medium that contains protein-free blood such as blood agar. Some species of bacteria produce the enzyme hemolysin which results in red blood cell lysis. The result is Beta hemolysis which is an enzyme that completely breaks down the red blood cells, making the area around the colonies of bacteria a clear and colorless zone. Alpha hemolysis is an enzymatic reaction which partially destroys red blood cells leaving a greenish hue around the colonies of bacteria. Gamma hemolysis: does not affect red blood cells. The test is conducted by placing 5% (v/v) of sterile sheep blood in the culture medium and incubation takes place within 24 hours at 37degC. In case the color of the culture in which the bacterial growths are located to a dark color, it signifies the presence of alpha hemolysis.

Determination of Heavy Metal Concentrations

To perform the mineral element analysis in meat brands, a digestion solution consisting of 10 ml of HNO_3 and HCl in a 2:1 (v/v) ratio was utilized to process 10 g of the meat brands. The solution was obtained by heating the mixture until clarity was achieved. The processed material underwent filtration and was subsequently diluted to a final volume of 100 ml using distilled water. Subsequently, measurements of lead, aluminum, iron, zinc, and tin were conducted utilizing an atomic absorption device. Standard solutions were carefully prepared for each metal element in accordance with the established standard [15].

Statistical Analysis

Statistical analysis was performed using the SAS system. Since the experimental design was a single-factor survey of different brands, a one-way analysis of variance (ANOVA) was applied to determine if significant differences existed among the 12 brands for each dependent variable (microbial counts and heavy metal concentrations). When the ANOVA indicated a significant overall difference ($p < 0.05$), pairwise comparisons between brand means were conducted using Fisher's Least Significant Difference (LSD) post-hoc test [16].

3- RESULTS AND DISCUSSION

3.1. Microbial Load and Safety Profile of Canned Meat Products

The microbiological analysis revealed that the total aerobic mesophilic counts across all 12 canned meat brands ranged from 1.0×10^1 to 1.0×10^3 CFU/g (Table 2). While these counts are relatively low, the detection of any viable aerobic microorganisms in commercially sterile canned products indicates a potential process deviation or post-processing contamination. Brand BH3 exhibited the highest count (1.0×10^3 CFU/g), whereas five brands (CH1, CH2, CH3, B1, BH1)

showed the lowest detectable level (1.0×10^1 CFU/g). A comparative analysis based on product category showed that beef hot dog samples had a higher mean microbial load than chicken hot dog samples, while chicken luncheon samples were more contaminated than beef luncheon samples (Fig. 2). These variations could be attributed to intrinsic factors such as the initial microbial quality of raw materials (chicken vs. beef), product formulation (pH, preservatives, spices), and differences in processing parameters among manufacturers [17]. The generally low microbial counts observed are likely a consequence of the combined lethality of the thermal process and the inhibitory effects of the canned environment (anaerobic conditions, low pH, and presence of preservatives) [17].

Table (2). Estimation of total bacteria count in canned meat brands.

No.	Brands (ID)	Total count of bacteria CFU/g
1	C1	40×10^1
2	C2	30×10^1
3	C3	20×10^2
4	CH1	1×10^1
5	CH2	1×10^1
6	CH3	1×10^1
7	B1	1×10^1
8	B2	10×10^1
9	B3	30×10^1
10	BH1	1×10^1
11	BH2	85×10^1
12	BH3	100×10^1

The contamination in beef hot dog brands was higher than in chicken hot dog brands in ,while contamination in chicken luncheon brands was higher than in beef luncheon. This difference may be due to many factors, including pH, raw material, i.e., the source of chicken or beef, as well as additives including colorants, spices, preservatives, etc. The combined effects of high temperature treatment, pH, preservatives and anaerobic condition of canning could have been responsible for the low microbial load's inmost cans [17]. In addition to the natural additives that are deliberately added to the product and have a positive effect on extending the shelf life, a study conducted by Abed et al., 2021 [18] examined the effects of various concentrations of rosemary volatile oil and Nisin A on the viable plate count of canned meat brands. The study's results indicated that meat brands treated with rosemary volatile oil exhibited 0 cfu/g after 9 days of storage, whereas brands treated with Nisin A, along with the control brands, showed 49 and 45 cfu/g, respectively.

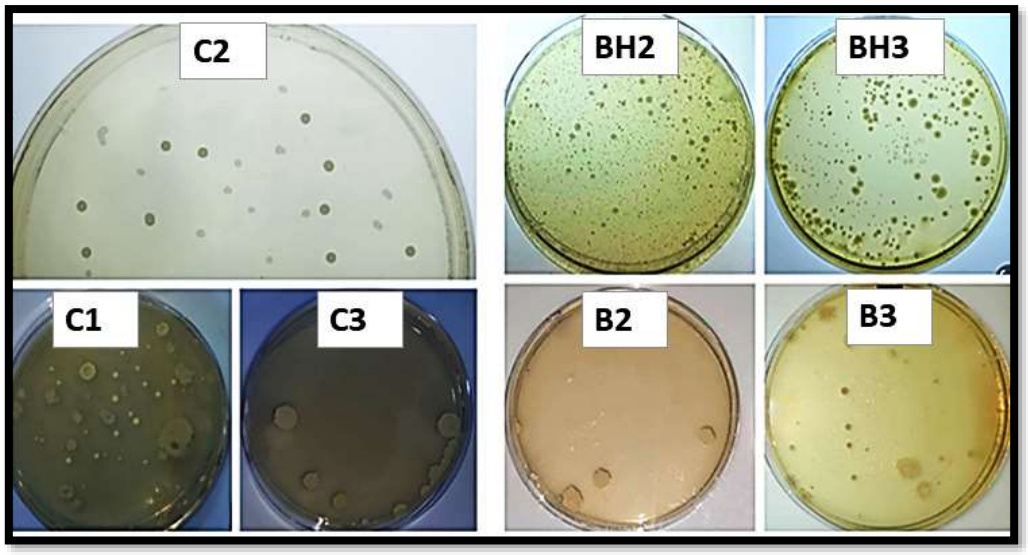

Fig (2). Show the colonies of bacteria in some brands of canned meat.

The findings align with previous studies reporting low but detectable microbial levels in canned meat products [19, 20], underscoring the necessity for stringent adherence to Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Point (HACCP) protocols throughout the production chain.

3.2. Isolation and Phenotypic Identification of Pathogenic Bacteria

Contrary to the expectation of sterility, conventional culture methods led to the isolation of presumptive pathogenic bacteria from 7 out of the 12 brands (58.3%) (Table 3). The isolated microorganisms were phenotypically identified as Staphylococcus aureus, Streptococcus spp., and Clostridium spp. based on Gram staining (Fig. 3), colony morphology on selective media, and a series of biochemical tests.

Table 3. Distribution of presumptiv

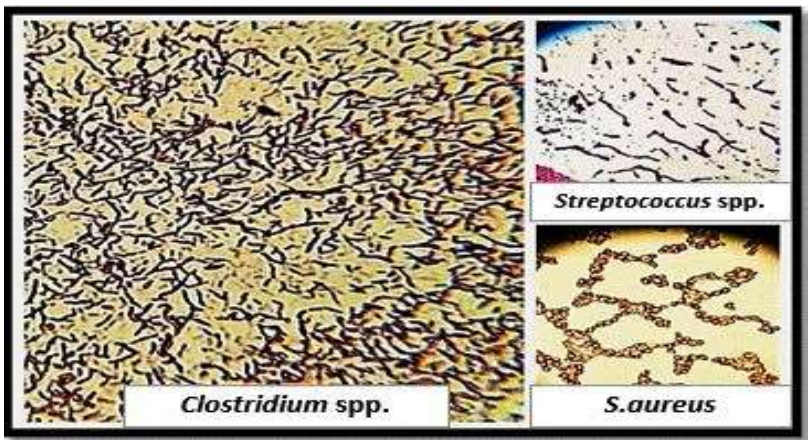

Fig (3). Bacterial isolates examination under electronic microscope.

S. aureus isolates were identified as Gram-positive cocci in clusters, catalase-positive, and capable of fermenting mannitol on Mannitol Salt Agar (MSA), producing

yellow colonies (Fig. 4). They also exhibited typical growth and acid production on Xylose Lysine Deoxycholate (XLD) agar (Fig. 7). The presence of *S. aureus*, a common indicator of poor hygiene during handling or post-processing, is particularly concerning due to its potential to produce heat-stable enterotoxins [21].

The *Streptococcus* spp. isolates were Gram-positive cocci in chains, catalase-negative, and showed β-hemolysis on Blood Agar. *Clostridium* spp., identified in one brand (C1), were Gram-positive, spore-forming bacilli grown under anaerobic conditions (Fig. 6) and tested positive for gelatin hydrolysis. The biochemical profiles of the isolates are summarized in Table 4. The detection of these microorganisms,
especially *Clostridium* spp., which includes neurotoxigenic species like *C. botulinum*, raises significant food safety concerns. It suggests possible under-processing during canning or, more likely, post-process contamination via seam defects or contaminated cooling water.

Table (3) Bacterial types from isolates of canned meat brands.

No.	Brands (ID)	Bacterial isolates
1	C1	Clostridium spp., S. aureus
2	C2	Staph. aureus
3	C3	Streptococcus spp., S. aureus
4	CH1	-
5	CH2	-
6	CH3	S. aureus
7	B1	-
8	B2	-
9	B3	S. aureus
10	BH1	Streptococcus spp.
11	BH2	-
12	BH3	S. aureus

Table (4). Biochemical tests of bacterial isolates from brands canned meat.

Bacterial isolates	S. aureus	Streptococcus spp., β-Hemolytic	Clostridium spp.
Colonies on blood agar	White to golden	Small white surrounded by clear zone	Grown in anaerobic conditions
Triple sugar iron agar	Positive	Acid/Acid	Variable
Catalase	Acid/Acid	Negative	Negative
Oxidase	Negative	Negative	Negative
Simmon's citrate	Negative	Negative	Negative
Urease	-	Negative	Negative
Indole	Positive	Negative	Negative
Gelatin utilization	Negative	Negative	Positive
Mannitol salt agar	Positive	-	-
Xylose Lysine Deoxycholate Agar (XLD)	Positive	-	-

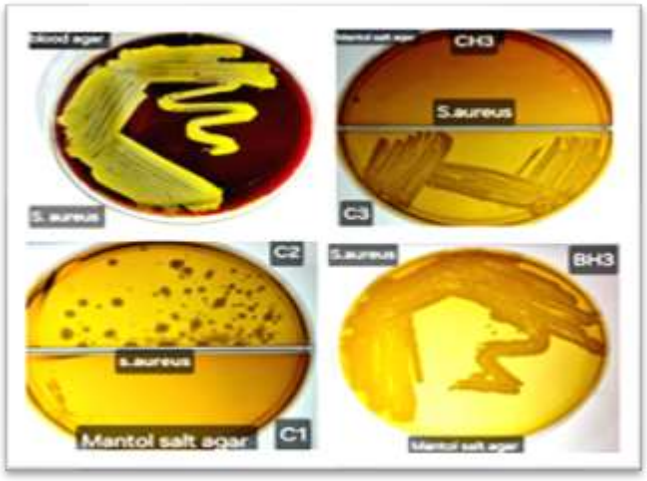

Fig (4). Staphylococcus aureus colonies on mannitol salt agar and blood agar.

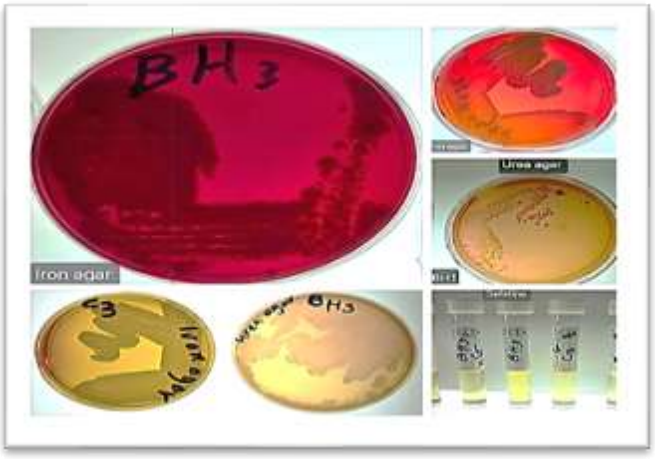

Fig (5). Staphylococcus aureus and Streptococcus spp. colonies on iron agar and urea agar.

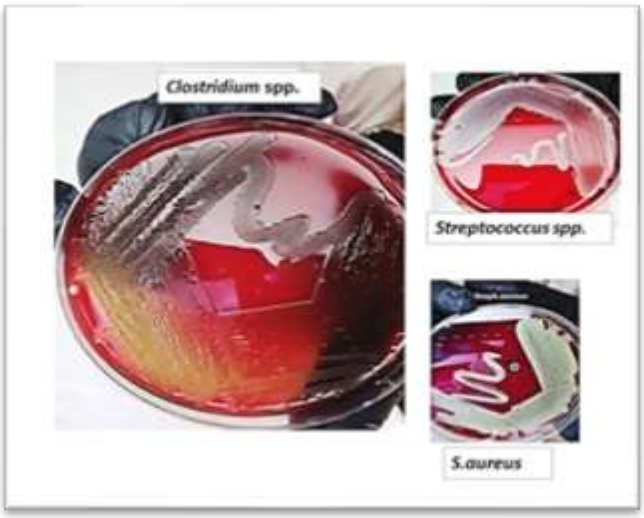

Fig (6). Clostridium spp. colonies on blood agar in C1 brand.

Fig (7). Staphylococcus aureus colonies on Xylose lysine deoxycholate agar (XLD) in (C1, C2, C3, CH3, B3, and BH3) brands.

3.3. Heavy Metal Contamination and Health Risk Assessment

The atomic absorption spectrometry analysis revealed detectable levels of lead (Pb), tin (Sn), zinc (Zn), iron (Fe), and aluminum (Al) in the canned meat samples (Table 5). Statistically significant differences ($p \leq 0.05$) were observed in the concentrations of all elements among the different brands.

Table (5). Concentration of heavy minerals in canned meat brands (mg/kg)

No.	Brands (ID)	Concentration of elements mg/kg (ppm)				
		Pb	Sn	Zn	Fe	Al
1	B1	0.000	0.823	19.123	387.083	0.025
2	B2	0.000	0.659	15.141	60.895	0.026
3	B3	2.117	0.379	16.606	40.294	0.012
4	BH1	4.235	0.564	20.363	46.398	0.004
5	BH2	0.000	0.808	17.019	55.554	0.020
6	BH3	1.323	0.257	18.560	54.791	0.037
7	C1	0.000	0.306	24.082	102.09	0.025
8	C2	0.000	0.514	16.568	57.080	0.125
9	C3	1.147	0.871	14.464	51.739	0.662
10	CH1	0.000	1.879	16.155	103.24	0.637
11	CH2	1.235	2.904	14.840	54.028	0.087
12	CH3	1.323	0.220	15.855	76.537	0.112
	L.S.D. value	0.782 *	0.695 *	3.041 *	11.87 *	0.126 *

* (P≤0.05).

Lead (Pb): The most critical finding was the Pb contamination in brand BH1, which recorded a concentration of 4.235 mg/kg. This value exceeds the maximum limit of 0.5 mg/kg set by the Codex Alimentarius for canned meats [22] by approximately 8.5-fold. It also surpasses the stricter EU limit of 0.1 mg/kg for meat (excluding offal) [23]. Lead is a cumulative neurotoxin that can cause anemia, hypertension, renal impairment, and cognitive deficits, particularly in children [22]. The source is likely leaching from soldered seams or contaminated raw materials.

Tin (Sn): All Sn concentrations were well below the permissible limit of 250 mg/kg for canned foods set by Codex and the EU limit of 200 mg/kg [24, 25]. The highest

level was 2.904 mg/kg (CH2), indicating no immediate toxicological concern from tin. However, the presence of Sn confirms interaction between the can and its contents.
Zinc (Zn) and Iron (Fe): Concentrations of Zn (14.464–24.082 mg/kg) and Fe (40.294–387.083 mg/kg) were within typical nutritional ranges for meat products. The high Fe content in some samples (e.g., B1: 387 mg/kg) could be beneficial from a nutritional standpoint but may also indicate contribution from the can lining or fortification.
Aluminum (Al): Al levels were low (0.004–0.662 mg/kg), posing no immediate health risk. Its presence may stem from additives, processing equipment, or environmental contamination.

4- Conclusion

This study demonstrates a concerning breach in the safety assurance of selected imported canned meats. The isolation of presumptive pathogens, including *S. aureus* and *Clostridium* spp., from 58.3% of samples points to significant deficiencies in processing hygiene or container integrity. Furthermore, the detection of lead at levels up to 8.5 times the international safety limit in one brand (BH1) represents a serious chemical hazard. These findings underscore an urgent need for enhanced regulatory oversight, rigorous border inspections, and the implementation of more sensitive detection methods to safeguard consumer health in the Iraqi market. Future work should employ molecular confirmation of pathogens and source-tracing of heavy metal contamination.

5- Acknowledgments

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6-REFERENCES

[1] Vågsholm, I., Arzoomand, N. S., & Boqvist, S. (2020). Food security, safety, and sustainability—getting the trade-offs right. Frontiers in sustainable food systems, 4, 487217.
[2] Abdullah, E. N. (2024). Estimation Of Contamination with Some Metallic Elements in Canned Processed Meat Products Available in Local Markets. Iraqi Journal of Agricultural Sciences, 2024:55(4):1502-1507.
[3] Tan, W. K., Husin, Z., Yasruddin, M. L., & Ismail, M. A. H. (2023). Recent technology for food and beverage quality assessment: a review. Journal of food science and technology, 60(6), 1681-1694.
[4] Al-Zaid, R. M. K., Al-Attar, E. J., & Hadi, M. T. (2023, April). Detection of mineral and microbial contaminants in some types of imported meat. In IOP Conference Series: Earth and Environmental Science (Vol. 1158, No. 11, 112025). IOP Publishing.
[5] Taman, L. R. A. (2003). Incidence of anaerobic bacteria in canned and cooked meat products.
[6] Mohd Abdullah, B. (2007). Properties of five canned luncheon meat formulations as affected by quality of raw materials. International Journal of Food Science and Technology, 42(1), 30-35.
[7] Zangana, B.S.R. and Al-Shamery, J.S.H., 2016. Effect of partial replacement of some plant sources in quality and sensory characteristics of processed of goose meat burger. Iraqi Journal of Agricultural Sciences, 47(4), 1089-110.
[8] Gupta, V. K., Gupta, M., & Sharma, S. (2001). Process development for the removal of lead and chromium from aqueous solutions using red mud—an aluminium industry waste. Water research, 35(5), 1125-1134.
[9] Chen, B., Chen, Z., & Lv, S. (2011). A novel magnetic biochar efficiently sorbs organic pollutants and phosphate. Bioresource technology, 102(2), 716-723.

[10] Nisreen, A. J., & Sirhan, M. M. (2021). Comparative study of removal pollutants (heavy metals) by agricultural wastes and other chemical from the aqueous solutions. Iraqi Journal of Agricultural Sciences, 52(2), 392-402.

[11] Olu-Taiwo, M., Obeng, P., & Forson, A. O. (2021). Bacteriological analysis of raw beef retailed in selected open markets in Accra, Ghana. Journal of Food Quality, 2021(1), 6666683.

[12] Qayyum, S., Basharat, S., Mian, A. H., Qayum, S., Ali, M., Changsheng, P., ... & Sultan, F. (2020). Isolation, identification and antibacterial study of pigmented bacteria. Applied Nanoscience, 10, 4495-4503.

[13] Procop, G. W., Church, D. L., Hall, G. S., & Janda, W. M. (2020). Koneman's color atlas and textbook of diagnostic microbiology. Jones & Bartlett Learning.

[14] Hemraj, V., Diksha, S., & Avneet, G. (2013). A review on commonly used biochemical test for bacteria. Innovare Journal of Life Science, 1(1), 1-7.

[15] Zalewski, K., Falandysz, J., Jadacka, M., Martysiak-Żurowska, D., Nitkiewicz, B., & Giżejewski, Z. (2012). Concentrations of heavy metals and PCBs in the tissues of European beavers (Castor fiber) captured in northeastern Poland. European Journal of Wildlife Research, 58, 655-660.

[16] SAS. 2018. Statistical Analysis System, User's Guide. Statistical. Version 9.6th ed. SAS. Inst. Inc. Cary. N.C. USA.

[17] Oranusi, S., Galadima, M., Umoh, V. J., & Nwanze, P. I. (2007). Food safety evaluation in boarding schools in Zaria, Nigeria, using the HACCP system.

[18] Abed, I. J., Ahmed, M. E., & MH AL-Shimmary, S. (2021). Rosemary volatile oil as a preservative agent in some canned meat foods. Iraqi Journal of Agricultural Sciences, 52(1).

[19] Hafez, N., & Khali, K. (2021). Quality Assurance of some imported canned meat products marketed in Fayoum city, Egypt. Fayoum Journal of Agricultural Research and Development, 35(1), 70-79.

[20] Pal, M., Ayele, Y., Patel, A. S., & Dulo, F. (2018). Microbiological and hygienic quality of Meat and Meat Products. Beverage Food World, 45(5), 21-27.

[21] Nader, Y. M., Mohamed, S. A., & Khalifa, E. M. (2016). Microbial quality of some canned meat and fish. Global Veterinaria, 16(6), 565-569.

[22] Series, T. F. (2009). Mercury, lead, cadmium, tin and arsenic in food. Food Safety, 1, 1-13.

[23] Salman, Z.O., Alwash, B.M.J. and Kadhim, E.J., 2019. Effect of essential oil of Cestrum nocturnum flowers cultivated in Iraq as antioxidant and elongation cold storage period of minced meat. Iraqi Journal of Agricultural Sciences, 50(2).

[24] Saba Jaafar Ajeena, Raed Mohammed Khalaf Al-Zaidi, Mayson Thafir Hadi, Maryam Malallah Ghazal. (2024). Study of the antioxidant activity of some active compounds in orange peels. Cell. Mol. Biol.,70(10),161-166.

[25] European Commission, E. (2006). Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. Off. J. Eur. Union, 364, 5-24.