" Kerbala Journal of Veterinary Medical Sciences, Vol. 1, Supplement I, 2025 "
"Proceedings of the 6th Scientific Conference, College of Veterinary Medicine, University of Karbala"

Detection of bisphenol-A accumulation in goat meat and edible products and the deleterious effect of its consumption

Athraa Abed Alradah Challab, Kadhim Saleh Kadhim, Juman Khaleel Al-Sabbagh

College of Veterinary Medicine, University of Kerbala , Kerbala , Iraq.
Corresponding author: juman.k@uokerbala.edu.iq
Received: 22/4/2025 **Accepted:**25/5/2025 **Published:** 3/7/2025

***Abstract*— Bisphenol A (BPA) and micro plastics (MPs) have been detected across various species, including humans, mammals, fish, birds, and invertebrates, indicating the potential for extensive exposure and bioaccumulation. Moreover, their prevalence has been increasing, contributing to an elevated risk of various pathological conditions. This research was undertaken to investigate the accumulation of BPA in edible tissues of goat such as (kidney, liver, meat and adipose tissues). Methodology: Hundred samples collected from 25 female's goat for edible tissues (meat, liver, kidney, and adipose tissue) aged between 6 and 8 months (25 samples from each tissue). The Karbala slaughterhouse for red meat in the Governorate was where tissue samples were taken between November 2024 and January 2025. Results: The results showed that, when judged against standard criteria, the average amounts of BPA buildup in these tissues ranged from moderate to high. The findings showed that while the kidney and meat each had medium concentrations (0.1-1 µg/g), the liver and fat had high BPA levels (over 1 µg/g). Bisphenol A (BPA) was most concentrated in the liver, in adipose tissues, then in meat, and last in the kidney. The application of the ANOVA analysis in current study facilitated the assessment of statistically significant differences among the four sample groups. The analysis revealed that liver and adipose tissues exhibited significant variation compared to kidney and muscle tissues, based on the obtained statistical parameters. In conclusion, the results underscore the toxicological risks associated with BPA. When exposure levels exceed the established daily tolerable intake which about 0.05 mg per kg /body weight, BPA can bioaccumulate in biological tissues, potentially leading to a range of adverse health effects.**

Keywords: BPA, Bioaccumulation, Edible parts, Kidney, Meat, Adipose tissues

INTRODUCTION

Red meat had played a significant role in human nutrition throughout evolutionary history. When consumed as the part of a diverse and balanced diet, the red meat also, served as a valuable sources of highly biological value protein, and several of the essential micronutrients are present in forms that exhibited greater bioavailability compared to those found in plant based or alternative food sources. Certain nutrients found in red meat, such as iron, zinc, and vitamin B12, have been recognized as commonly deficient in specific population subgroups (1). Furthermore, meat and meat edible products rank among the densest components of the nutrient human diet. They served as the significant sources of energy and provide a wide range of essential nutrients, including protein with high quality, bioavailable micronutrients such as zinc, iron, and selenium, and the key vitamins such as B-complex like B12, B6, and folic acid. Additionally, they contained several bioactive components such as carnitine, taurine, ubiquinone, glutathione, carnosine, and creatine that, contributed to the various metabolic processes. Historically, meat has played a crucial role in human evolution and continues to be an integral part of a nutritious, balanced diet (2). Goats are remarkably resilient and productive small ruminants, valued for their ability to thrive in diverse ecological conditions. Despite their agricultural importance, goat meat production and consumption remain underutilized globally. Yet, this sector holds significant promise in addressing food security challenges, particularly for a growing population (3). In many developing countries, goat meat serves as a vital source of animal protein, though its consumption is still limited in numerous regions. Recently, however, shifting consumer attitudes—fuelled by increasing recognition of the health benefits of lean, low-fat, and low-cholesterol meats—have spurred greater interest in goat meat (4,5). At the same time, a pressing concern arises from the presence of endocrine-disrupting compounds (EDCs) in the environment. These chemicals pose substantial risks to both human health and ecosystems by interfering with hormonal regulation. Such disruptions can lead to widespread adverse effects across multiple species (6).

These exogenous agents can mimic or inhibit endogenous hormones, disrupting reproductive and developmental processes in diverse species (7). One of the most widely studied endocrine-disrupting compounds (EDCs) is bisphenol A (BPA), which exerts its toxic effects primarily through estrogenic activity, impairing physiological functions in multiple organ systems. From a chemical perspective, BPA is a hydroxyphenyl propane derivative featuring two phenol rings, each with hydroxyl groups at the *para* positions. This unique structure enhances its reactivity, allowing BPA to participate in electrophilic substitution reactions and form various derivatives, such as ethers, esters, and salts (8). Given its bioactive properties and pervasive environmental presence, maintaining heightened awareness of the risks associated with chronic low-dose BPA exposure is critical (3).

However, further epidemiological studies are necessary to conclusively determine the relationship between BPA exposure and adverse health effects. In the meantime, healthcare providers should prioritize educating women—particularly those planning pregnancy or currently pregnant—about the potential risks of BPA exposure and effective mitigation strategies (9). Microplastics (MPs) had been investigated in various animal species, including mammals, birds, fish, and also, invertebrates, that indicated the potential widespread for bioaccumulation, and environmental exposure thus upon ingestion, MPs can be interacted with the gastrointestinal system, and potentially affecting, composition of gut microbiota, nutrient absorption and overall digestive function. Additionally, MPs may be served as the carriers for the other chemical contaminants, thereby enhancing their bioavailability and exacerbating their toxic effects on several animals, while some studies suggesting that MPs can lead to adverse health outcomes in animals such as oxidative stress, inflammation, and endocrine processes disruption, the full extent of the health impacts and long-term consequences of the exposure of MPs on nutrition of animal still remains uncertain (10).

MATERIALS AND METHODS

A total of 100 samples were collected from 25 female goats, with 25 samples obtained from each of the following edible tissues; muscle, liver, kidney, and adipose tissue. The tissue samples were sourced from the Karbala red meat slaughterhouse in the Karbala Governorate, between November 2024 and January 2025. Samples were collected 24 hours prior to the extraction process and were stored at 4°C to maintain their integrity. BPA residues were extracted from the tissue samples using organic solvents. Following extraction, the resulting extracts were analysed for BPA content using high-performance liquid chromatography (HPLC).

***Extraction of BPA from Living Tissues:**

The method of extraction utilized in this study was a modified adaptation of the multiresidue analysis technique described in a previous study (11). About 5 grams of meat and edible tissues were separately weighed, crushed, and homogenized. To each sample, added 25 mL of acetonitrile, and the mixture was agitated for 30 minutes by using a magnetic stirrer, followed by 15 minutes standing period. Subsequently, the liquid phase was separated, and the extract at 45,000 rpm for 15 minutes was centrifuged to eliminate the solid residues. The resulting supernatant was transferred to an Erlenmeyer flask and placed in a fume hood above a water bath heated to below 50°C, where it was allowed to evaporate completely. Once dried, the residue in the flask was washed with one mL of acetonitrile, then was collected in an opaque glass vial. Until that, 100 µL of solvent A and 150 µL of solvent B were added.

The samples were forwarded to the laboratory of the Materials Research Department at the Ministry of Science and Technology in Baghdad for analysis via high-performance liquid chromatography (HPLC) (12). The chromatographic conditions were as follows: the mobile phase comprised a 60:40 mixture of methanol and distilled water, and a C18-ODS column (25 cm × 4.6 mm) was employed. UV-Vis. detection was carried out at wavelengths of 224 or 220 nm. The flow rate was maintained at 0.7 mL/min, and the injection volume was 20 µL (13).

Ethical Approval: The research adhering to ethical principles derived from the Declaration of Helsinki. The protocol of this study, subject information, and consent form underwent review and received approval from a local ethics committee under the reference number (UOK.VET.HE. 2024.093).

RESULT & DISCUSSION

In the present study, following the extraction procedure for detecting BPA accumulation in biological tissues, the results presented in Table (1), illustrate the mean concentrations of BPA across different tissue types in comparison to established reference standards. Elevated concentrations of BPA (greater than 1 µg/g) were observed in the liver and adipose tissues, whereas moderate levels (ranging from 0.1 to 1 µg/g) were detected in the kidney and muscle tissues.

Table 1. Types of tissues and average concentration of BPA as compared to standard criteria

Tissues	Average of BPA (µg/g)	Classification
Liver	1.97	High
Kidney	0.71	Medium
Meat	0.64	Medium
Adipose tissues	1.2	High

Classification Criteria:

- **Low concentration: less than 0.1 µg/g**
- **Medium concentration: 0.1 – 1 µg/g**
- **High concentration: more than 1 µg/g**

The analytical procedure was optimized and validated for the detection of aglycone BPA specifically in adipose tissue, as well as for total BPA across all examined tissue types. In contrast, edible tissues from the control group of rams were generally found to be free of BPA contamination (14). The exposure to BPA at low doses in different animals had been linked to a huge range of adverse effects, including carcinogenic, neurological, and also, reproductive impacts; such as an increased susceptibility of breast and prostate cells to carcinogenesis (15). Despite uniform exposure doses, varying BPA concentrations were detected in the tissues of exposed rams, particularly in adipose tissue. Therefor these differences were largely attributed to individual variations in bioavailability and metabolic processing, as well as inherent analytical uncertainties (16).

In this study the concentration of BPA detected in (Meat, Liver, Kidney and Adipose tissues) of goat, the results found there were a significant difference among these tissues as cleared in table (2).

Table 2: ANOVA analysis for *P value* of BPA in goat meat and edible parts

	liver	**kidney**	**meat**	**Adipose tissues**	***P value***
Tissues of goat	1.97 ± 0.421 a	0.71 ± 0.214 b	0.64 ± 0.24 b	1.20 ± 0.23 a	**0.019***

***P value* < 0.05 is significant**

In this study, BPA concentrations were quantified in four edible goat tissues: liver, kidney, muscle, and adipose tissue. The findings demonstrated that the liver contained the highest BPA concentration, followed by adipose tissue, muscle, and kidney, in descending order. Statistical analysis using one-way ANOVA revealed significant differences in BPA concentrations across the examined tissues. Post-hoc comparisons showed notably higher BPA accumulation in hepatic and adipose tissues compared to renal and muscular tissues ($p < 0.05$), with these findings supported by robust statistical parameters.

In 2023, the study investigating BPA's effects on hormonal regulation in animal models found that chronic exposure resulted in significant bioaccumulation, particularly in hepatic and renal tissues. These elevated BPA levels showed strong correlations with multiple pathological alterations, including tissue inflammation, endocrine dysfunction, and metabolic disorder development (17). The study employed a targeted analytical approach to measure total BPA concentrations in edible tissues, specifically designed to evaluate bioaccumulation patterns in rams following repeated low-dose exposure (18).

Previous studies had been reported that, BPA concentrations ranging from 1 to 2 µg/kg in similar matrices, aligning with findings by multiple research groups (19, 20). These consistent measurements across independent studies suggest reliable detection of baseline environmental BPA contamination levels. The estimated mean contributions of aglycone BPA from the edible tissues of the treated rams to the potential daily intake relatively to the European Union's former temporary tolerable daily intake (TDI) which at about 4 µg/kg body weight/day were calculated as 0.06%, 0.04%, 0.01%, and 0.004% for the total daily food basket (including meat and offal), liver, kidney, and adipose tissue, respectively. However, these contributions become markedly more significant when assessed against the recently proposed and substantially reduced TDI of 0.04 ng/kg body weight/day (21). That, highlighting the potential health implications of even though minimal BPA exposure under updated regulatory standards.

The liver served as a primary site for the metabolism of a wide array of many chemical compounds, including environmental toxicants such as BPA, owing to its extensive enzymatic systems that facilitated the biotransformation and detoxification of xenobiotics. Meanwhile, this high metabolic activity also renders hepatic tissue particularly vulnerable to the accumulation of such compounds, resulting in elevated BPA concentrations within the liver (22). Besides, the kidneys determine the key organs in the excretion of metabolic waste and toxic substances especially prone to chemical accumulation due to their filtration function, making them another critical site for BPA deposition (23). Moreover, BPA's lipophilic nature promotes its preferential storage in adipose tissue, contributing to the relatively higher concentrations detected in fat compared to other organ systems (24).

Conclusion

The findings of this study highlighted the toxicological significance of BPA. When exposure exceeds the tolerable daily intake threshold of 0.05 mg/kg/body weight. So, BPA has the potential to bioaccumulate in different biological tissues, including meat, liver, kidney, and adipose tissue. This accumulation may lead to a range of adverse health effects, underscoring, the importance of regulating BPA exposure to mitigate potential risks to human and animal health.

REFERENCES:

1) Wyness L. (2016). The role of red meat in the diet: nutrition and health benefits. The Proceedings of the Nutrition Society, 75(3), 227–232. https://doi.org/10.1017/S0029665115004267
2) Stadnik J. (2024). Nutritional Value of Meat and Meat Products and Their Role in Human Health. *Nutrients*. 16(10):1446. doi:10.3390/nu16101446
3) Webb EC. (2014). Goat meat production, composition, and quality. Animal Frontiers, 4(4) : 33–37. https://doi.org/10.2527/af.2014-0031
4) Kukovics S. (2023). Goat Science - Environment, Health and Economy. IntechOpen (Ed.). doi: 10.5772/intechopen.87510
5) Lamri M, Djenane D, and Gagaoua M. (2022). Goat meat consumption patterns and preferences in three provinces of Kabylia region in Algeria compared to other meat species: Results of an online survey. Meat Technology, 63 (2): 96-108. https://doi.org/10.18485/meattech.2022.63.2.3
6) Deraz RH, El-Demerdash M, and Ibrahim NA. (2013). Endocrine Disrupting Chemicals; Myths & Facts. ESCTJ; 1: (1). 10.21608/esctj.2013.62848
7) Czarny-Krzymińska K, Krawczyk B, and Szczukocki D. (2023). Bisphenol A and its substitutes in the aquatic environment: Occurrence and toxicity assessment. Chemosphere, 315 (137763). https://doi.org/10.1016/j.chemosphere.2023.137763.

8) Gingrich A, and Lutter C. (2021). Kinship and gender relations across historical Asia and Europe: An introduction to comparative reassessments between the 8th and 19th centuries CE, History and Anthropology, 32:2: 143-150, DOI: 10.1080/02757206.2021.1905235

9) Akash MSH, Rasheed S, Rehman K, Imran M, and Assiri MA. (2023). Toxicological evaluation of bisphenol analogues: preventive measures and therapeutic interventions. *RSC advances*, 13(31), 21613–21628. https://doi.org/10.1039/d3ra04285e

10) Manzoor MF, Tariq T, Fatima B, Sahar A, Tariq F, Munir S, Khan S, Nawaz Ranjha MMA, Sameen A, Zeng X-A and Ibrahim SA. (2022). An insight into bisphenol A, food exposure and its adverse effects on health: A review. Front. Nutr. 9:1047827. doi: 10.3389/fnut.2022.1047827

11) Kwintkiewicz J, Nishi Y, Yanase T, and Giudice LC. (2010). Peroxisome proliferator-activated receptor-γ mediates bisphenol a inhibition of FSH-stimulated IGF-1, aromatase and estradiol in human granulosa cells. Environmental Health Perspectives; 118: 400-406. 10.1289/ehp.0901161

12) Matuszczak E, Komarowska MD, Debek W, and Hermanowicz A. (2019). The Impact of Bisphenol A on Fertility, Reproductive System and Development: A Review of the Literature. Int. J. Endocrinol.; 4068717. 10.1155/2019/4068717

13) Hamad FS, Al-Sabbagh JK, and Kadhim KS. (2024). The Role of Biodegrading-bacteria to Remove Bisphenol-A from Polluted Soils. Uttar Pradesh Journal of Zoology; 45 (12): 114-124. 10.56557/upjoz/2024/v45i124110

14) Cerkvenik-Flajs V, Škibin A, Švara T, Gombač M, Sabina P, and Šturm S. (2022). Bisphenol A in edible tissues of rams exposed to repeated low-level dietary dose by high-performance liquid chromatography with fluorescence detection. Environmental Science and Pollution Research 29:76078–76090 https://doi.org/10.1007/s11356-022-21154-5

15) Leranth C, Hajszan T, Szigeti-Buck K, Bober J, and MacLusky NJ. (2008). Bisphenol A prevents the synaptogenic response to estradiol in hippocampus and prefrontal cortex of ovariectomized nonhu man primates. PNAS USA, 105(37):14187-14191. https:// doi. org/10.1073/pnas.0806139105

16) Deceuninck Y, Bichon E, Gény T, Veyrand B, Grandin F, Viguié C, Marchand P, and Le Bizec B. (2019). Quantitative method for con jugated metabolites of bisphenol A and bisphenol S determina tion in food of animal origin by Ultra High-Performance Liquid Chromatography-Tandem Mass Spectrometry. J Chromatogr A, 1601:232–242. https://doi.org/10.1016/j.chroma.2019.05.001

17) Molina-López AM, Bujalance-Reyes F, Ayala-Soldado N, Mora-Medina R, Lora-Benítez A, and Moyano-Salvago R. (2023). An Overview of the Health Effects of Bisphenol A from a One Health Perspective. *Animals*. 3(15):2439. https://doi.org/10.3390/ani13152439

18) Cerkvenik-Flajs, V. and Šturm, S. (2021). A rapid analysis of Bisphenol A using MISPE coupled with HPLC-FLD in tissues of food-producing animals. MethodsX, (8): 101351.

19) Nunez AA, Kannan K, Giesy JP, Fang J, and Clemens LG. (2001). Effects of bisphenol A on energy balance and accumulation in brown adipose tissue in rats. Chemosphere. 42(8):917-922. doi: 10.1016/S0045-6535(01)00167-9.

20) Shao B, Han H, Li D, Ma Y, Tu X, and Wu Y. (2007). Analysis of alkylphenol and bisphenol A in meat by accelerated solvent extraction and liquid chromatography with tandem mass spectrometry. Food Chem. 105:1236-1241. doi: 10.1016/j.foodchem.2007.02.040.

21) EFSA (2022). Bisphenol A: EFSA draft opinion proposes lowering the tolerable daily intake. 2021. https://www.efsa.europa.eu/en/news/bisphenol-efsa-draft-opinion-proposes-lowering-tolerable-daily-intake. Accessed 6 Jan 2022

22) Fritsche K, Ziková-Kloas A, Marx-Stoelting P, and Braeuning A. (2023). Metabolism-Disrupting Chemicals Affecting the Liver: Screening, Testing, and Molecular Pathway Identification. *International Journal of Molecular Sciences*. 24(3):2686. https://doi.org/10.3390/ijms24032686

23) González-Parra E, Herrero JA, Elewa U, Bosch RJ, Arduán AO, and Egido J. (2013). Bisphenol a in chronic kidney disease. Int J Nephrol. 2013:437857. doi:10.1155/2013/437857

24) Cohen IC, Cohenour ER, Harnett KG, and Schuh SM. (2021). BPA, BPAF and TMBPF Alter Adipogenesis and Fat Accumulation in Human Mesenchymal Stem Cells, with Implications for Obesity. *International Journal of Molecular Sciences*. 22(10):5363. https://doi.org/10.3390/ijms22105363