ISSN: 2458-8989

Natural and Engineering Sciences

NESciences, 2025, 10 (1): 425-435 doi: 10.28978/nesciences.1651206

The Impact of Chemical Residues in Meat Products on Human Nutritional and Health

Luay Salam Khaleefah [1*], Mahdi Hassan Hussain [2], Haneen Abdulamir Alasady [3]

[1*] Green University, Department of Food Science, College of Food Science, Al-Qasim, Babylon, Iraq. E-mail: luaysalam@fosci.uoqasim.edu.iq

[2] Green University, Department of Food Science, College of Food Science, Al-Qasim, Babylon, Iraq. E-mail: dr.mahdihassan@fosci.uoqasim.edu.iq

[3] Department of Dairy Science, College of Food Science, Al-Qasim Green University, Al-Qasim, Babylon, Iraq. E-mail: haneen@fosci.uoqasim.edu.iq

Abstract

This study aimed to identify specific chemical pollutants in sausages, lunch meat, minced meat, and burgers. In all, 172 meat product samples (43 of each burger, minced meat, lunch meat, and sausage) were gathered from several local markets in the Iraqi provinces of Baghdad and Babil. The quantities of progesterone, zeranol, and trenbolone hormone residues, Additionally, the samples' levels of pesticide residues were tested. The mean values of 1.0055, 0.6166, and 0.8222 ppb for sausage, minced meat, and luncheon meat, respectively, the occurrence of zeranol residue in burgers was zero and 100%. Trenbolone traces were found in every meat product sample that was examined, including sausages, lunch meat, minced beef, and burgers. The corresponding mean values for these residues were 0.2372, 0.3181, 0.3094, and 0.3261 ppb. Progesterone residues were measured in every burger, minced meat, lunch meat, and sausage samples that were analyzed. The mean values of these residues were 0.0638, 0.0827, 0.0455, and 0.0366 ppb, respectively. All analyzed samples of burgers, minced meat, lunch meat, and sausages had PP.DDT residues are found in them. Minced beef had a higher mean PP than other meat product sample's DDT value (2.9880 ppm). Only the burger and minced meat samples had methoxychlor residues, with mean values of 49.5820 and 48.9938 ppm; lunch meat and sausage samples did not have methoxychlor residues—however, PP. DDE was absent from every sample. All burgers, minced beef, lunch meat, and sausage samples had their PP. DDD recorded mean values of 0.872, 0.903, 0.914, and 0.982. As a result, we must regularly check for chemical residues like hormones as a precautionary measure for food quality and pesticides in certain meat products since these residues present a severe danger to public health.

Keywords:

Hormone residues, meat, zeranol, progesterone, trenbolone, toxins, pesticide residues.

Article history:

Received: 25/11/2024, Revised: 27/01/2025, Accepted: 17/02/2025, Available online: 31/03/2025

*Corresponding Author: Luay Salam Khaleefah, E-mail: luaysalam@fosci.uoqasim.edu.iq

Introduction

Human nutrition depends on meat and animal products, yet they also cause pollution. like hormones and pesticides that humans consume. There are numerous ways for contaminated materials to get into the food chain (Yilmaz & Demirhan, 2020). Veterinary medications may leave residues in animal products, and these pollutants in water, other foods, and forages can spread to animal products (Rashidi & Shafei, 2014). Al-Amri et al., (2021). In animal production, the use of drugs that pose health risks, like growth-promoting agents and hormones, is a persistent issue (Doust, 2017). These substances are frequently employed to boost productivity and lower breeding expenses (Manyi-Loh et al., 2018). Among other hazardous compounds are pesticides, such as DDT used on crops; it can lead to cancer, liver problems, and infertility in animals DDT and other toxins can permeate fat and accumulate in animal fat. Chlorinated hydrocarbons, such as toxaphene, endrin, dieldrin, heptachlor, and aldrin, have been the worst pesticides. (Syed et al., 2023). The recent decades, the frequency with which hormones and other hormonally active compounds have been found in animal-based meals has increased globally. Human and animal endocrine glands produce and excrete trace amounts of chemical signaling substances called hormones. They are essential to maintaining homeostasis, preventing metabolic imbalance, and preventing the illnesses that follow from it. As the common precursor, cholesterol synthesizes all steroid hormones (Brown et al. 2012). The only structural differences between them are side chain modifications and the configuration of chemical bonds within the rings. Protein transformed into muscle deposition is essential to meat producers (Evans et al., 2022). The American Association estimates that Sixty-three percent of American beef cattle have growth-promoting hormone implants. The livestock business may see improved yields and revenues when they are used. The production of veal and beef can be increased by up to 15% when farm animals are given hormonal active growth boosters (Qaid & Abdoun ,2022). Age, breed, species, reproductive health, and hormone administration all have a role; yields can reach 40% (Evans et al., 2022). In recent decades, there has been a dramatic increase in the potential harm that hormone residues & their metabolites could cause to consumers because agricultural animals transfer these substances to their edible tissue and bodily fluids, and consequently, to finished products of animal origin (Gržinić et al., 2023). Consumers who consume animal-based meals can be subjected to extra hormonal activity that may have an effect on the body's many physiological systems and, ultimately, human health because an animal's inherent hormones and hormones obtained through diet have the same impact. While it is strictly forbidden in the European Union, certain nations allow using specific hormones as growth boosters in agricultural animals (Pleadin & Samardžija 2019). It is crucial to note that different nations have different laws and different scientific opinions about the use of specific β-agonists in the livestock business, such as ractopamine, zilpaterol, and clenbuterol. Remainders in animal-derived food Farm animals have anabolic effects when hormonally active drugs are administered at doses 10- to 15-fold more excellent than the recommended dosages. However, these chemicals also spread to body fluids and edible tissue, and eventually, they show up as residues in animal-based foods (Yusuf and Abrahim 2023). Fusarium species produce zeranol (α-zearalenone) as an anabolic agent, a nonsteroidal oestrogenic mycotoxin (Noori, 2023). To promote body weight gain and feed efficiency, it is used as an animal implant., and meat quality. Withdrawal of zeranol is relatively lengthy; 96.3% of patients are released After 65 days of implantation, the zeranol concentration decreases in every organ and tissue below 2 parts per billion (μg kg−1) (Zhang et al. ,2018). There should be no more than 0.05, 10, and 2 parts per billion of zeranol in a person's regular diet, Cattle muscle, and liver. The liver may contain zeranol residues up to 120 days following implantation, with the maximum concentrations in edible tissues 14 days post-administration (Tresise ,2014). Overview of insecticides Living animals can be exposed to OCPs by breathing in contaminated air or consuming tainted water and animal feed. OCP residues can enter the human body by consuming tainted animal tissues, milk, and other dairy products. Infertility, cancer, and liver disorders in animals can result from the application of pesticides & other very harmful chemicals such as DDT in crops. DDT and other toxins can permeate fat and accumulate

in animal fat. The Persistent Organic Pollutants Convention of Stockholm has 179 signatories since it was adopted in May 2001 (Castrejón-Godínez et al., 2022). The first 12 POP compounds prohibited by this treaty were chlordane, toxaphene, dieldrin, endrin, heptachlor, hexachlorobenzene, DDT, aldrin, and mirex. These can be discovered only by examining environmental samples for contamination (Devi, 2020). Dieldrin and DDT (4,4′-dichlorodiphenyltrichloroethane) are classified as 2A by the International Agency for Research on Cancer or most likely harmful to human cancer (Assegid & Ketema, 2023). In contrast, other OCP compounds, such as Toxaphene, hexachlorocyclohexanes, hexachlorobenzene, heptachlor, and chlordane, belong to the category 2B, which includes potential Carcinogens to humans. Group 1 chemicals known to cause human cancer include lindane and polychlorinated biphenyls (Nandhinieswari & Indumathi, 2024). There is DDT in various foods, particularly those from animals (Dziurakh et al., 2024; Said & El Zokm 2024). According to the research, exposure to OCP compounds from Dairy products, meat, and meat products, fish, as well as additional fruits can account for more than 90% of the total. Buffaloes are subject to a range of xenobiotics during their lifetimes, including pesticides, heavy metals, mycotoxins, and antibiotics. Consuming contaminated milk and other edible tissues can allow these contaminants to enter the human body, negatively impacting the animal (Năstăsescu et al., 2020). This investigation assessed the progesterone hormone levels, trenbolone, zeranol, and pesticide (organochlorine) residue in burgers, minced meat, lunch meat, and sausage.

Material and Methods

Sample Collection

One hundred seventy-two samples (43 of each type) of ground beef, burgers, lunch meats, and sausage were purchased from local markets in Baghdad and Babylon.

Methods

- ***Anabolic Steroid Residue Determination***
    - BioPharma Germany's AG Darmstadt RIDA_SCREEN Zeranol, quantitative enzyme immunoassay Zeranol measurement, ELISA method for detecting zeranol residues.
    - The use of enzyme immunoassay in the quantitative measurement R-bio pharm AG-Darmstadt, Germany, of trenbolone RIDASCREEN® Trenbolone, Identification of trenbolone residues by (ELISA) technique (Uzunov, Hajrulai-Musliu et al. 2013).
    - The ELISA method is used to detect progesterone residues, as per R-bio pharm RIDASCREEN AG-Darmstadt, Germany Progesterone, Using Enzyme Immunoassay to Quantify Assessment of Progesterone (Uzunov, Hajrulai-Musliu et al. 2013).

Pesticide Detection

Gas Chromatography (GC) was used to detect organophosphorus and organochlorine pesticides by (Wondimu & Geletu, 2023)

Analysis of Statistics (S. A, S. 2001):

The acquired A statistical analysis of numerical data was conducted for the least significant difference and analysis of variance. When necessary, correlation, chi-square, and t-test calculations were made.

Results

Table 1 displays the hormone residues. It reveals showed all of the burger samples had 0% zeranol residues. (43 samples) at 100%. At the same time, they were recorded in all lunch meat, sausages, and minced meat (43 samples each) at 100% with an average value of 0.6166, 0.8222, and 1.0055 ppb, respectively. The sausage had the greatest zeranol concentration, 1.2 ppb. However, trenbolone residues were found in 43 of each sample of burger, minced meat, lunch meat, and sausages (100%) that were tested. The burgers, minced beef, lunch meat, and sausage samples had the highest trenbolone residue levels (0.37 ppb), with the average values being 0.2372, 0.3181, 0.3094, and 0.3261 ppb, respectively. Additionally, the burgers, minced beef, lunch meat, and sausage samples had average progesterone residue levels of 0.06388, 0.0827, 0.0455, and 0.0366 ppb, respectively. The sample of minced meat had the highest progesterone level, 0.09 ppb. This study examined organochlorine pesticide (OCP) levels in sausages, burgers, lunch meats, and minced beef samples. The findings in Table 2 indicated that Methoxychlor, PP-DDD, and PP-DDT were the final three groups of organochlorine pesticides found to have good outcomes. While minced meat had the most significant levels of PP-DDDT (2.9880 ppm) and methylchlor (49.5820 ppm), sausages had the highest levels of PP-DDD (0.982 ppm). Only residues of organochlorine pesticides were found in the scrutinized Luncheon meat and sausage samples: PP-DDD was 0.917 and 0.982 (ppm), whereas PP-DDT was 1.9402 and 2.948 (ppm), respectively. Nevertheless, the burgers' residual levels of PP. DDT, Methoxychlor, and PP. DDD was 2.7211, 48,9938, and 0.872, respectively. Methoxychlor was not found in luncheon meat or sausage, although No PP. DDE was detected in any of the analyzed meat samples.

Table 1: Residues of some hormones in meat product samples.

Zeranol_(ppb)						
	% +ve	Min.	Max.	Mean	SE ±	STD.DEVIATION
Luncheon meat	100%	0.5	0.9	0.822222	0.026266054	0.111437429
Burger	0%	0	0	0	0	0
Minced_Meat	100%	0.3	0.8	0.616667	0.043723732	0.185504083
Sausage	100%	0.6	1.2	1.005556	0.043138493	0.183021125
Progesterone (ppb)						
	% +ve	Min.	Max.	Mean	SE ±	STD.DEVIATION
Luncheon meat	100%	0.02	0.06	0.045556	0.002173	0.009218
Burger	100%	0.04	0.07	0.063889	0.00216	0.009164
Minced Meat	100%	0.04	0.09	0.082778	0.003111	0.013198
Sausage	100%	0.01	0.04	0.036667	0.001808	0.00767
(ppb) Trenbolone						
	% +ve.	Min.	Max	Mean.	S.E.±	STD.DEVIATION
Luncheon meat	100%	0.08	0.36	0.309444444	0.019744648	0.083769447
Burger	100%	0.2	0.27	0.237222222	0.004263047	0.018086575
Minced Meat	100%	0.03	0.38	0.318181818	0.019049681	0.080820951
Sausage	100%	0.08	0.37	0.326111111	0.021114981	0.089583276

Table 2. Residues of some pesticides in meat product samples

The name of (ocp) Calculated (ppm)				
	PP. DDD	PP. DDT	Methoxychlor	PP. DDE
Luncheon meat	-	1.94026	-	0.917
Burger	-	2.72116	48.99381	0.872
Minced Meat	-	2.98801	49.58206	0.903
Sausage	-	2.948	-	0.982

Discussion

The regulation of the utilization of such hormones varies significantly across different regions of the world. The EEC, or European Economic Community, prohibited using anabolic agents to stimulate livestock growth. In contrast, USFDA, the US Food and Drug Administration authorized the restricted application of certain naturally occurring hormones (including Progesterone, testosterone, and estrogen) & specific artificial hormones (such as Acetate of melengestrol, zeranol, and acetate of trenbolone) in the veterinary industry. Risto et al., (2013) Anabolic steroids are administered to calves for growth enhancement 60 to 90 days before slaughter. Concentrations of hormone residues in consumable tissues are elevated in treated animals compared to untreated ones, and there is apprehension that hormonal residues, especially from synthetic sources, may lead to detrimental reproductive effects in those consuming beef. Three to six The European Union prohibited this (Qaid & Abdoun ,2022). The WHO has stipulated that zeranol residues must not surpass 0.05 parts per billion in daily the diet of humans, In bovine muscle, 2 ppb, and 10 ppb in the liver of cows. The present analysis yielded values beyond the allowed levels established by European Commission regulations, as shown in Table 3. This means that the aforementioned acceptable tolerance limits must be promptly considered when applying zeranol in animal husbandry and regulating meat and meat products in Iraq.

The WHO tolerance limit for zeranol residues was surpassed in 52 samples in this study (74% of the total) Table 1, with the reported quantity likely corresponding to daily human consumption in 3 samples. This suggests that these 3 samples may pose a potential health risk to consumers, particularly concerning minced meat, which is prevalent in numerous meals. The examined burger samples did not exceed the maximum residual limits established by EC 1999 and Codex 1997Zeronol's absence in the analyzed burger samples may stem from the impact of freezing on zeranol decrease, aligning with findings reported by (Abd El-Shahid, 2021). Recent years have seen a growing focus on the role that hormones have in the etiology of breast cancer, prompted by reports of elevated Endogenous hormone levels, exposure to exogenous hormones, and other endocrine-disrupting substances. Due to its prevalence as food contamination, avoiding the consumption of zeranol is challenging. They are utilized independently or in conjunction with TBA as a hormone that promotes development in diverse animals (Qaid & Abdoun ,2022). In vitro investigations offer definitive proof that zeranol causes breast cancer. Treatments with zeranol repeatedly demonstrated a reduction in the Time it takes for cells to double, stimulation of the establishment of colonies, and, most significantly, the induction of mRNA for ER-β expression in the human breast epithelial cell line MCF_10A. (Agahi et al. 2020). in human breast cancer cells that are ER-positive, modest concentrations of zeranol were observed to enhance cell proliferation, whereas these concentrations had no impact on the growth of ER-negative cells. Zeranol promoted Both ER-positive and ER-negative cells undergo apoptosis. at elevated concentrations. Conversely, exposure to environmental estrogens has been directly correlated with breast cancer tissues 14 days post-administration (Jing et al. 2022). Compounds of mycotoxin exhibit specific hazardous characteristics, notably their estrogenic effects. Furthermore, Zeranol diminished the expression of the estrogen-regulated potential tumor suppressor gene in human breast cancer, protein tyrosine phosphatase γ. Elevated serum leptin levels enhance the sensitivity of both standard and malignant breast cells to the presence of Zeranol in beef (Leu ,2022).

Trenbolone

Identified in all 70 samples (100%) (Table 1), the residues in the carcasses remained at parts per billion levels. The allowable limit for trenbolone is 2 parts per billion in muscle and 10 parts per billion in liver (Novo et al., 2021). The concentration of trenbolone did not surpass the tolerance threshold in any samples, peaking at 0.38 parts per billion in the ground beef sample. This outcome was determined to be beneficial for consumer health.

Progesterone

Although progesterone levels were most significant in the ground beef sample at 0.09, as per the Codex Alimentarius, the maximum residue limit (MRL) for progesterone in cattle has not been definitively established due to its classification as a natural hormone in animals (Smith ,2024). The inherent levels of progesterone in meat and dairy products are typically minimal, and it is posited that the regular consumption of these items does not endanger human health. Furthermore, the Food Additives Joint FAO/WHO Committee (JECFA52) evaluation suggests the acceptable daily intake ranges between 0 and 30 μg/kg of body mass (Cinar ,2024).

Hormonal Traces in Meat and Dairy Products and How they Affect Public Health

Despite inevitable carcinogenic consequences, the WHO announced that 2000 saw a maximum safe intake each day of progesterone 0.03μg/kg per day for female humans, asserting that it does not impact fertility, pregnancy, or breastfeeding in treated women (Rath et al., 2018). All naturally occurring anabolic steroids, including testosterone, progesterone, and estradiol appear to be safe, with the main hazards to health stemming from the implant site's ingestion, mainly when administered in inappropriate locations or through repeated treatments or multiple implants in certain animals (Badawy et al,. 2021,). Progesterone elevates. The incidence of breast, and uterine tumors in experimental animals. Residual hormones in meat and their impacts The European Food Safety Authority (EFSA) identified in 2007 data linking some types of hormone-dependent malignancies to red meat eating, which may harm consumer health (Qaid & Abdoun ,2022). Certain hormones administered to animals may not be fully absorbed or digested, raising concerns regarding the potential consequences of residues in milk, eggs, and meat. Apprehension regarding the safety of hormones inherently encompasses. The possibility of hazards associated with ingesting products originating from animal food products. Investigating dietary patterns and additional risks associated with cancer Menopausal women's development has determined that consumption eating dairy products could raise the chance of developing ovarian cancer. (He et al., 2021). Our investigation into processed meat's effects on fertility in men and pregnant women revealed a negative correlation between processed red meat consumption and total sperm count as well as total progressive motility (Benatta et al., 2020). Elevated Anabolic steroid dosages can diminish HDL stands for high-density lipoprotein, augment Lipoprotein low in density (LDL), heighten the possibility of developing serious coronary heart disease, can hinder the body's immune response.Therefore, the utilization of anabolic substances in the care of animals must be rigorously regulated (Albano et al., 2021).

Impact of Hormones on the Environment

Hormones in animal products such as meat and milk and in soil and water derived from animal Excrement may negatively impact aquatic and terrestrial wildlife glandular function. (Marlatt et al., 2022). An investigation was carried out on a sample of youth in Diwaniyah Governorate, southern Iraq, revealed, as per the research titled. The lack of health regulation over food has resulted in the addition of harmful substances to chickens for fattening purposes, leading to an increase and imbalance of hormones in males (Barakat & Hady ,2017). One potential cause of hormonal alterations in adolescents may be the elevated hormone concentrations in water, particularly given that the northern region of Diwaniyah Governorate in Babil Governorate contains extensive meadows for cattle rearing intended for meat production. These results are consistent with (Bai et al., 2020). A study in northern Iraq revealed elevated hormone levels in imported beef products available in the markets of Iraqi Kurdistan (Murad et al., 2016).

Food Preparation and Hormones

Regulation of hormonally active compounds Hormonally active chemicals are known to stay in the animal tissues that can be eaten, and heat treatment cannot neutralize or eliminate these molecules (Guo et al. 2024).

Specific carcass characteristics may be influenced by implants or implant procedures across the lifespan, resulting in diminished processing rates, lower yield, worse beef quality, flavor, and overall carcass quality. Hormonal therapy diminishes meat softness, prolongs cooking duration, and decreases nutritional value (Gómez et al., 2020).

Pesticide Residues in Meat and How they Affect Human Health

Unlike other organochlorine chemicals, DDT residues exhibit higher adipose tissue concentrations than muscle or lean meat. Owing to its elevated fat content, its remains are present in the fatty tissues of all animals, including humans (Achour et al., 2023). Researchers indicate that the hazards of pesticides may begin as early as the embryonic stage of development. Breast milk may transmit maternal antibodies to newborns or transfer them via the placenta to the fetus. Certain oral contraceptive pills may harm an individual's health (Mathiesen et al., 2020). Children are particularly vulnerable to pesticides owing to their low stature and developmental immaturity (Buralli, Marques et al. 2023). Previous investigations on pesticide residues in milk and baby meals indicated elevated residual levels above permissible limits. In the instance of DDT, 82% of the 2,205 bovine milk samples were contaminated, with about 37% exceeding 0.05 mg/kg is the tolerance level established by the Food Safety Adulteration Act for whole milk (Oo ,2023). The positive samples identified various DDT isomers, including pp-DDT, pp-DDE, and pp-DDD. The findings indicate (Table 2) that DDT continues to be used unlawfully in Iraq. Prolonged exposure to these hazardous pollutants via food consumption can result in intoxication and contribute to numerous health issues affecting the immunological, neurological, endocrine, reproductive, hepatic, and skin systems, potentially leading to chronic diseases and the emergence of various cancers (Machate, 2023). DDT remains in the soil for Only the third decade of the 30-year period saw a decrease in DDT residues. DDT may undergo microbial transformation under aerobic soil conditions, producing DDE and DDD are stable and dangerous metabolites. Conversion rate is influenced by organic carbon and soil concentration, temperature, and amount of moisture. DDT's half-life in soil used for agriculture varies from four to thirty-five years, with an average of 10 to 10.5 years (Gohil & Ogram 2020).

Research on the distribution of DDT in the tissues of animals indicates which DDE is predominant component, although the proportions of DDT and DDD fluctuate DDE is gradually excreted, accumulating over time in animal tissues relative to the other DDT enantiomers. Consequently, this enantiomer of DDT is the most stable. (Arenas et al. 2022). Items for which pesticide residues were not discovered cannot be said to be free of such residues; it can only be confirmed that the studied batch does not contain pesticide residues. This study is a novel examination of pesticide residues in some meat products. It is very significant since the intake of these items is associated with the onset of overweight and non-communicable illnesses, rendering them inadvisable.

Conclusions

A recent assessment of veterinarian Growth, both natural and artificial enhancers in animals that produce food, shows a rising understanding of their health hazards. Anabolic development boosters for poultry or farm animals may harm people and animals. As endocrine disruptors, synthetic anabolic hormones harm Food and the environment. The research found that natural anabolic steroids like progesterone, testosterone, and estradiol are safe and tolerable, with the only health concern being implant ingestion. Illegal usage of β-agonists like clenbuterol is limited due to their thermal stability and oral activity. BST prioritizes socioeconomics above public health. High anabolic content meat and animal products may damage consumers; hence, they must be appropriately regulated when applied to farm animals. Some hormones that promote growth in agricultural animals include GHs, β-agonists, and implants of anabolic steroids. Different mechanisms boost agricultural animal productivity by improving milk production, carcass quality, feed conversion efficiency, or average

daily gain. Hormones that promote growth are essential for the production of animals, but consumers might experience carcinogenic consequences. Human growth-promoting hormones and their unlawful use should be stopped or regulated until risk evaluations are done. Countries should restrict hormonal and other animal growth stimulants. New therapeutic uses as growth promotors and the effects of endogenous and exogenous hormones on population health, farm animal and wildlife health, and the environment require more study. Toxins from pesticides may accumulate in the body and persist in the liver. Consequently, it is strongly recommended to consistently monitor for OCP residues in both animal and plant-based meals.

Author Contributions

All Authors contributed equally.

Conflict of Interest

The authors declared that no conflict of interest.

References

Abd El-Shahid, E. Y. M. (2021). *Chemical residues in meat Products* (Doctoral dissertation, Benha University).

Achour, A., A. Derouiche, M. R. Driss and O. Tebourbi (2023). "Organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) in adipose tissue of women from Grand Tunis and their association with demographic factors and dietary habits." *Chemosphere* 338: 139600.

Agahi, F., G. Font, C. Juan and A. Juan-García (2020). "Individual and combined effect of zearalenone derivates and beauvericin mycotoxins on SH-SY5Y cells." *Toxins 12*(4): 212.

Al-Amri, I., I. T. Kadim, A. AlKindi, A. Hamaed, R. Al-Magbali, S. Khalaf, K. Al-Hosni and F. Mabood (2021). "Determination of residues of pesticides, anabolic steroids, antibiotics, and antibacterial compounds in meat products in Oman by liquid chromatography/mass spectrometry and enzyme-linked immunosorbent assay." *Vet World 14*(3): 709-720.

Albano, G. D., Amico, F., Cocimano, G., Liberto, A., Maglietta, F., Esposito, M., ... & Montana, A. (2021, January). Adverse effects of anabolic-androgenic steroids: a literature review. *In Healthcare 9*(1), 97. MDPI. https://doi.org/10.3390/healthcare9010097

Arenas, M., J. Martín, J. L. Santos, I. Aparicio and E. Alonso (2022). "Enantioselective behavior of environmental chiral pollutants: A comprehensive review." *Critical Reviews in Environmental Science and Technology 52*(17): 2995-3034.

Assegid, W., & Ketema, G. (2023). Harnessing AI for Early Cancer Detection through Imaging and Genetics. *Clinical Journal for Medicine, Health and Pharmacy*, *1*(1), 1-15.

Badawy, M. T., M. Sobeh, J. Xiao and M. A. Farag (2021). "Androstenedione (a natural steroid and a drug supplement): a comprehensive review of its consumption, metabolism, health effects, and toxicity with sex differences." *Molecules 26*(20): 6210.

Bai, R., Huang, Y., Wang, F., & Guo, J. (2020). Associations of fluoride exposure with sex steroid hormones among US children and adolescents, NHANES 2013–2016. *Environmental Pollution, 260*, 114003.

Barakat, D. A. and F. A.-A. H. Hady (2017). "Effect of frozen meat in the hormonal imbalance in male in the Diwaniyah city."

Benatta, M., R. Kettache, N. Buchholz and A. Trinchieri (2020). "The impact of nutrition and lifestyle on male fertility." *Archivio Italiano Di Urologia e Andrologia 92*(2).

Buralli, R. J., R. C. Marques and J. G. Dórea (2023). "Pesticide effects on children's growth and neurodevelopment." Current Opinion in Environmental Science & Health 31: 100417. https://doi.org/10.1016/j.coesh.2022.100417

Castrejón-Godínez, M. L., A. Rodríguez, E. Sánchez-Salinas, P. Mussali-Galante, E. Tovar-Sánchez and M. L. Ortiz-Hernández (2022). Soils Contaminated with Persistent Organic Pollutants (POPs): Current Situations, Management, and Bioremediation Techniques: A Mexican Case Study. *Pesticides Bioremediation, Springer:* 413-453.

Cinar, C. (2024). Adapting food preferences: the social, emotional, and genetic roots of preferences for meats versus plants.

Devi, N. L. (2020). "Persistent organic pollutants (POPs): environmental risks, toxicological effects, and bioremediation for environmental safety and challenges for future research." *Bioremediation of Industrial Waste for Environmental Safety: Volume I: Industrial Waste and Its Management:* 53-76.

Doust, A. V. (2017). Comparison of general health between migrant men and women inhabitant of Emam town in Chamestan city. *International Academic Journal of Social Sciences, 4*(1), 198–206.

Dziurakh, Y., Kulyniak, I., Sarkisian, H., Zhygalo, I., Chepil, B., & Vaskovych, K. (2024). Intrusion Detection Systems for Smart Tourism Platforms: Safeguarding Food Safety and User Privacy. *Journal of Internet Services and Information Security, 14*(4), 484-498. https://doi.org/10.58346/JISIS.2024.I4.030

Evans, H. C., Briggs, E. F., Burnett, R. H., Contreras-Correa, Z. E., Duvic, M. A., Dysart, L. M., ... & Memili, E. (2022). Harnessing the value of reproductive hormones in cattle production with considerations to animal welfare and human health. *Journal of animal science, 100*(7), skac177.

Gohil, H. and A. Ogram (2020). "The microbial degradation of DDT and potential remediation strategies." *Bioremediation Technology:* 1-24.

Gómez, I., R. Janardhanan, F. C. Ibañez and M. J. Beriain (2020). "The effects of processing and preservation technologies on meat quality: Sensory and nutritional aspects." *Foods 9*(10): 1416.

Gržinić, G., A. Piotrowicz-Cieślak, A. Klimkowicz-Pawlas, R. L. Guo Górny, A. Ławniczek-Wałczyk, L. Piechowicz, E. Olkowska, M. Potrykus, M. Tankiewicz, M. Krupka, G. Siebielec and L. Wolska (2023). "Intensive poultry farming: A review of the impact on the environment and human health." *Science of The Total Environment* 858: 160014.

Guo, Z., X. Feng, G. He, H. Yang, T. Zhong, Y. Xiao and X. Yu (2024). "Using bioactive compounds to mitigate the formation of typical chemical contaminants generated during the thermal processing of different food matrices." *Comprehensive Reviews in Food Science and Food Safety 23*(5): e13409.

He, Y., Q. Tao, F. Zhou, Y. Si, R. Fu, B. Xu, J. Xu, X. Li and B. Chen (2021). "The relationship between dairy products intake and breast cancer incidence: a meta-analysis of observational studies." *BMC cancer 21*: 1-12.

Jing, S., C. Liu, J. Zheng, Z. Dong and N. Guo (2022). "Toxicity of zearalenone and its nutritional intervention by natural products." Food & Function 13(20): 10374-10400.

Leu, A. F. (2022). Pesticide safety in livestock products. In *Managing Healthy Livestock Production and Consumption* (pp. 73-91). Academic Press.

Machate, D. J. (2023). "Anthropogenic hyperactivity for natural resources increases heavy metals concentrations in the environment: Toxicity of healthy food and cancer risks estimated." *Journal of Trace Elements and Minerals 4:* 100057.

Manyi-Loh, C., S. Mamphweli, E. Meyer and A. Okoh (2018). "Antibiotic Use in Agriculture and Its Consequential Resistance in Environmental Sources: Potential Public Health Implications." *Molecules 23*(4).

Marlatt, V., S. Bayen, D. Castaneda-Cortès, G. Delbès, P. Grigorova, V. S. Langlois, C. J. Martyniuk, C. D. Metcalfe, L. Parent and A. Rwigemera (2022). "Impacts of endocrine disrupting chemicals on reproduction in wildlife and humans." *Environmental Research 208*: 112584.

Mathiesen, L., T. A. Mørck, M. S. Poulsen, J. K. S. Nielsen, T. Mose, M. Long, E. Bonefeld-Jørgensen, R. Bossi and L. E. Knudsen (2020). "Placental transfer of pesticides studied in human placental perfusion." *Basic Clin Pharmacol Toxicol 127*(6): 505-515.

Murad, H. O., F. A. Muhamad, A. Y. Hamadameen, S. New and K. Region (2016). "Identification and quantification of anabolic steroids in imported frozen beef muscles in sulaimani market using HPLC." *Pakistan Journal of Food Sciences 26*(2): 72-82.

Nandhinieswari, S., & Indumathi, A. (2024). Bilevel optimized recursive feature eliminator for cervical cancer feature selection process. Archives for Technical Sciences, 2(31), 311–328. https://doi.org/10.70102/afts.2024.1631.311

Năstăsescu, V., M. Mititelu, M. Goumenou, A. O. Docea, E. Renieri, D. I. Udeanu, E. Oprea, A. L. Arsene, C. E. Dinu-Pîrvu and M. Ghica (2020). "Heavy metal and pesticide levels in dairy products: Evaluation of human health risk." *Food and Chemical Toxicology 146*: 111844.

Noori, A. M. (2023). Spatiotemporal Land Cover Transformation Assessment of Kirkuk City Using Remote Sensing Data. *International Journal of Advances in Engineering and Emerging Technology, 14*(1), 8–15. Retrieved from https://erlibrary.org/erl/index.php/ijaeet/article/view/3

Novo, C. S., A. Barros, V. Feddern, A. Coldebella and G. N. Scheuermann (2021). "Determination of Eleven Veterinary Drugs in Chicken Meat and Liver."

Oo, K. (2023). Effects Of Pesticides on Human Health, EPA.

Pleadin, J. and M. Samardžija (2019). "Hormonally active substances in the food chain from farm animals to consumers." *Veterinarska stanica 50*(6): 501-512.

Qaid, M. M. and K. A. Abdoun (2022). "Safety and concerns of hormonal application in farm animal production: A review." *Journal of Applied Animal Research 50*(1): 426-439.

Rashidi, M., & Shafei, R. (2014). Using structural equation modelling to survey Corporate Image components in the Food manufacturing. International Academic Journal of Economics, 1(1), 59–66.

Rath, A. P., S. Panda, R. Pandey, A. Routray and K. Sethy (2018). "Hormone residues in milk and meat products and their public health significance." *Pharm. Innov. J 7*(1): 489-494.

Risto, U., Zehra, H. M., Biljana, S. D., Elizabeta, D. S., Aleksandra, T., & Velimir, S. (2013). Validation of screening method for determination of methyltestosterone in fish. *Maced. Vet. Rev*, *36*, 19-23.

Said, T. O., & El Zokm, G. M. (2024). Persistent Organic Pollutants in Aquatic Systems. *Classification, Toxicity, Remediation and Future Springer*, 1.

Smith, B. (2024). "Profitability of growth-enhancing technologies in Canadian feeder cattle production."

Syed, S., S. Qasim, M. Ejaz, Sammar, N. Khan, H. Ali, H. Zaker, E. Hatzidaki, C. Mamoulakis, A. Tsatsakis, S. T. A. Shah and S. Amir (2023). "Effects of Dichlorodiphenyltrichloroethane on the Female Reproductive Tract Leading to Infertility and Cancer: Systematic Search and Review." *Toxics 11*(9).

Tresise, M. M. (2014). The use of selected biomarkers to determine the effects of veterinary growth stimulants in the Mozambique tilapia (Oreochromis mossambicus), University of Johannesburg (South Africa).

Wondimu, K. T. and A. K. Geletu (2023). "Residue analysis of selected organophosphorus and organochlorine pesticides in commercial tomato fruits by gas chromatography mass spectrometry." Heliyon 9(3): e14121.

Yilmaz, S., & Demirhan, S. A. (2020). Age, growth parameters and food composition of Invasive Red Lionfish (Pterois volitans L., 1758) in İskenderun Bay. *Natural and Engineering Sciences, 5*(2), 82-91. https://doi.org/10.28978/nesciences.756730

Zhang, G. L., Y. L. Feng, J. L. Song and X. S. Zhou (2018). "Zearalenone: A Mycotoxin with Different Toxic Effect in Domestic and Laboratory Animals' Granulosa Cells." *Front Genet 9*: 667.