Research Article

Recognition of Aromatic Hydrocarbon Compounds in Some Grilled Beef Products on the Egyptian Market by Gas Chromatography-Mass Spectrophotometry Technique

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Abstract | Eighty random samples of grilled Egyptian meat samples, including kabab, kofta, burger, and shawerma (20 of each), were obtained from restaurants throughout the Menoufiya governorate in Egypt. By using the gas chromatography–mass spectrometry (GC–MS) technology, all collected samples were examined for the presence of certain polycyclic aromatic hydrocarbons (PAHs), and comparison of their contents with the recommended standard limits. Regarding the obtained findings, kabab recorded the highest concentrations of PAHs and PAH4 (the sum of four different polycyclic aromatic hydrocarbons, named benzo[*a*]anthracene, chrysene, benzo[*b*]fluoranthene, and benzo[*a*]pyrene) made it of the highest health risk to the consumers, followed by kofta, shawarma and burger, respectively. Besides that, positive samples were compared with the European Commission Regulations (EC) of the maximum permissible PAHs limits in the meat products (≤12 µg\kg); so, 20 (25.0%) of the examined samples were compatible for human consumption safely. Conclusively, the present surveillance indicated the safety of some grilled commercial RTE meat products in Egypt for human consumption in relation to PAHs concentrations with special reference to its health hazards. Moreover, it is highly recommended to look for safe, especially of natural origins, to reduce PAHs concentrations in the grilled meat products after exposure to smoking and processing techniques making it safer for human consumption.

Keywords | PAHs, Ready-to-Eat, Meat products, GC-MS, Egypt.

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INTRODUCTION

Processed meat products are defined as meats that have been treated by various ways such as curing, smoking, dehydration, or other processes to improve their flavor or wholesome. Meat products are an essential part of the human diet, and their consumption has been rising globally in the last years. Such meals are not only an excellent source of energy and nutrients as different minerals and vitamins, but they are also necessary for contemporary society's survival (Ursachi et al., 2020).

Despite these benefits, the image of the processed and RTE meat products meats for consumers has become negative; that recent studies showed strong associations between consumption of processed red meat and many risks such as pancreatic cancer (You et al., 2022) and colorectal cancer (IARC, 2015).

Processed meats have been thought to increase risk of cancer because of production of various carcinogenic chemicals during processing and cooking, such as PAHs, which are mostly related with the way of meat processing in high temperatures (Cheng et al., 2021).

Polycyclic aromatic hydrocarbons (PAHs) are groupings of more than hundreds assimilated aromatic combinations mainly originate by incomplete ignition of organic molecules, thermal decaying of organic matters frequently utilized as energy sources, and industrial incinerations, and emitted in cigarette smoke and automobile exhaust (Lawal, 2017).

Thermal-treatment of meat by such ways of smoking, pan-frying, grilling and barbecuing lead to increased PAH concentrations and contribute significantly to human PAH uptake. The generation of PAHs is influenced by the processing technique, temperature, duration, lipids and oil. Due to pyrolysis of organic compounds at high temperatures, large amounts of PAHs have been released (Lee et al., 2016).

As a result, the World Health Organization's- International Agency for Research on Cancer (WHO-IARC) allocated processed beef products as "carcinogenic to humans" (Group I). Furthermore, each 50-gram quantity of processed meat consumed daily raises the risk of colon cancer by 18%, according to the findings (IARC, 2015).

Thus, there is a considerable interest and need, not only for wholesome meat production and processing, but also for its safety and fitness for human consumption even in the long run. As a result, the current study attempted to identify the presence of PAHs in a variety of commercial RTE meat products in Egypt, including kabab, kofta, burgers, and shawerma, collected from random restaurants located in Menoufiya governorates, Egypt by GC-MS technique.

MATERIALS AND METHODS

Collection of samples

A total of eighty grilled beef samples (charcoal grilled kabab, kofta; and pan grilled burger and shawerma, 20 of each) were randomly obtained from different marketplaces in the Egyptian Menoufiya governorate. The gathered samples were analyzed for detection of polycyclic aromatic hydrocarbon and comparison of their contents with the recommended standard limits as well as determination of their acceptability for human consumption.

Determination of Polycyclic Aromatic Hydrocarbons (PAHs)

Chemicals: For getting the samples ready for PAHs analysis, ethanol sodium sulphate, cyclohexane, sodium chloride, N, N-dimethylformamide, HPLC grade-methanol and potassium hydroxide were purchased from El-Gomhurya Co., Al-Amirya, Egypt. Besides that, Silica solid phase extraction tubes (500 mg), Ultrapure water, and a mixture of 12 PAHs standards (Benz[a]anthracene (BaA), benzo[a]pyrene (BaP), benzo(b)flourathene (BpF), benzo[g,h,i]perylene (BghiP), chrysene (CHR), cyclopenta[c,d]pyrene (CPP), dibenzo[are]pyrene (DaeP), dibenz[a,h]anthracene (DahA), dibenzo[ash]pyrene (DahP), di-benzo[a, i]pyrene (DaiP), dibenzo[a,l]pyrene (DalP) and indeno[1,2,3-cd]pyrene (IcdP)) were purchased from AccuStandard (CT06513, USA).

Samples preparation: The tested meat product was mixed-well and prepared following the recorded procedures by Simko (2002) and Stumpe et al. (2008) with some modifications to accommodate the detection technique of gas chromatography–mass spectrometry (GC–MS).

Gas chromatography with mass selective detector (GC–MS): Modularity was used for analysis with Thermo Scientific Gas Chromatography (GC) and Gas Chromatography Mass Spectrometry (GC/MS) Systems. The following were the operating conditions: Factor Varian helium carrier gas 1 cm3/min, injector and detector temperature 280°C, temperature program: 120°C (1 min), 120-250°C (15°C/min), 250°C (13 min), 250-280°C (20°C/min), 280°C (1 min), 280-300°C (35°C/min), 300°C (1 min), 300°C (1 min), 300°C (1 min), 300°C (1 min), 300°C (1 min), 300°C (1 min (20 min). The show lasted 48 minutes in total. 1950 volts was the ionizing voltage.

A gas chromatograph was used to inject one liter of the prepared sample solution. The data was collected when the MS was in the chosen ion monitoring mode. Peak spectra were matched to PAH standards and the library that came with the device.

Detection time (minutes) and monitored ions (m/z) were recorded in Table (1).

Recovery: The results of the recovery of PAHs from the different examined meat products were evaluated according to the technique adopted by Chantara and Sangchan (2009). Accurately, the recovery percentages were ranged from 91% to 100% for the various studied meat products. For each PAH, the average of triplicate analyses was computed.

Quality control: For each set of samples, the process and reagent blanks were examined and subtracted from the sample analysis.

Table 1: Detection time (minutes) and monitored ions (m/z) of PAHs detection in GC-MS

Detection time (Minutes)	Monitored Ions (m/z)
5.00 - 20.00	226 - 228- 242
20.01 - 32.00	250- 252- 264 - 276- 278
32.01 - 48.00	150 - 302

Table 2: Concentrations of PAH (μg/kg) in the examined RTE processed meat products (n=20)

PAH	Burger	Kabab	Kofta	Shawerma	*P*-value* (between the examined products)
BaA	8.5±1.1	14.8±1.5	11.3±1.4	10.7±1.4	0.009
BaP	4.8±0.09	12.8±2.0	11.0±1.8	9.7±1.7	0.016
BghiP	3.3±0.07	6.3±0.09	5.7±0.08	4.6±0.8	0.133
BpF	1.1±0.3	2.4±0.05	2.0±0.06	1.5±0.4	0.312
CCP	2.6±0.1	5.5±0.12	4.5±0.01	3.7±0.8	0.367
CHR	1.8±0.3	3.3±0.03	2.9±0.04	2.3±0.3	0.055
DaeP	0.17±0.02	0.24±0.04	0.16±0.02	0.12±0.01	0.049
DahA	0.3±0.01	0.86±0.03	0.7±0.02	0.6±0.2	0.542
DahP	ND	ND	ND	ND	---
DaiP	0.15±0.03	0.26±0.04	0.19±0.04	0.16±0.03	0.321
DalP	0.26±0.01	0.67±0.02	0.5±0.02	0.4±0.1	0.528
IcdP	2.9±0.07	5.1±0.08	3.7±0.08	3.0±0.7	0.182

* Significant statistical differences were recorded when *P*-value ≤ 0.05

Table 3: Statistical analysis of PAH4 (μg/kg) in the examined RTE meat products (n=20)

Meat product	Min.	Max.	Mean ± SE
Burger	2.78	33.40	$14.1±1.8^{d}$
Kabab	11.90	58.10	$30.0±2.9^{a}$
Kofta	5.30	47.50	$23.9±2.5^{b}$
Shawerma	4.40	45.10	$21.5±2.5^{c}$

PAH4 is the total sum of BaP, BaA, BbF, and Chr

[abcd] Different superscript letter indicating significant difference when $P ≤ 0.05$

Table 4: Fitness of the examined samples for human consumption (n=20)

Meat product	MPL (μg/kg) *	Accepted samples		Unfit samples	
	PAH4 ≤12 (μg/kg)	No.	%**	No.	%**
Burger		9	45.0	11	55.0
Kabab		1	5.0	19	95.0
Kofta		4	20.0	16	80.0
Shawarma		6	30.0	14	70.0
Total***		20	25.0	60	75.0

* Most Permissible Limit (MPL) according to the European Regulation (EC) No. 1881 (2011); Amend (2020).

PAH4 is the total sum of BaP, BaA, BbF, and Chr

** In relation to the total number of each examined meat product samples (20).

*** In relation to the total number of the examined samples (80).

Statistical Analysis

According to Arkkelin (2014), the whole obtained data were examined using the Analysis of Variance (ANOVA) test in SPSS software V.20.

Separately, PAH4 (the sum of four different polycyclic aromatic hydrocarbons, named benzo[a]anthracene, chrysene, benzo[b]fluoranthene, and benzo[a]pyrene) was calculated and recorded.

RESULTS AND DISCUSSION

Smoked meat products have been manufactured from fat and muscle of wholesale cuts or some non-muscle parts (liver) (Jira et al., 2013). Smoking is the process of infusing meat products with volatiles produced by the thermal decomposition of wood. As a desirable outcome of smoking, phenolic compounds are produced, which are critical to the organoleptic qualities of smoked meat products (Oz, 2020).

PAHs are a class of pollutants that result from the partially burned organic compounds (pyrolysis) (IARC, 2012). Higher intake of processed beef was linked to an overall increased risk of death, according to a 10-year study, which was attributable to the risk of carcinogenesis PAHs and saturated lipids (National Cancer Institute, 2010); in addition, it reported the risk of PAH benzo[a]pyrene (BaP) on experimental animals, it showed various toxicological and carcinogenic effects included haemato-toxicity, reproductive and developmental toxicity and immunotoxicity.

The current surveillance targeted on PAH4 (sum value of BaP, BaA, CHR and BbF). Also, the contents of 12 PAHs (BaA, BaP, BghiP, BpF, CCP, CHR, DaeP, DahA, DahP, DaiP, DalP and IcdP) were analyzed. European Commission Regulation (EU) (2011) has set the maximum permissible limit (MPL) for PAH4 in processed meats ≤12 μg/kg and the maximum limits of BaA of 2 μg/kg.

Regarding with the obtained data, Table (2) showed that BaA recorded the highest concentration among the analyzed PAHs in the examined meat products, where its mean values in the examined burger, kabab, kofta and shawarma were 8.5±1.1, 14.8±1.5, 11.3±1.4 and 10.7±1.4 μg/kg, respectively. In addition, kabab samples recorded higher PAHs values than the other examined samples with reported significant values between the examined products in the BaA and BaP mean values with p-values of 0.009 and 0.016, respectively; while non-significant difference was recorded in the other PAHs values between the examined products when the p-value ≤0.05.

As a significant fitness parameter, PAH4 values (BaA+BaP+BbF+CHR) were summed and calculated. Recorded mean values in Table (3) indicated that kabab samples recorded the highest PAH4 concentration (30.0±2.9 μg\kg), followed by kofta (23.9±2.5 μg\kg), shawerma (21.5±2.5 μg\kg) and burger came the least (14.1±1.8 μg\kg). Furthermore, Table (4) presented the compatibility of the examined samples for human consumption in reference with the European commission regulations (EC) No. 1881 (2011): A. (2020) relating to the PAH4 concentrations in different examined meat products, where that out of the eighty examined samples, 60 (75.0%) of the examined samples recorded higher PAH4 values than the permissible limit regarding them unfit for human consumption. Moreover, burger samples recorded the highest fitness value (45.0%) with lower PAH4 value (14.1±1.8 μg\kg), followed by shawarma, kofta and kabab with compatibility percent in 30.0, 20.0 and 5.0%, respectively.

Marked higher levels of PAHs and PAH4 with lower compatibility rated of kabab samples than the other examined samples may be associated with time of exposure and temperature of processing; in addition to the quality and fullness of combustion and smoking process (Sampaio et al., 2021).

In comparison with previously reported records, the obtained results of PAHs and PAH4 concentrations could be compared with those recorded by Barakat (2021) who conducted a study investigating occurrence of some carcinogenic compounds in processed meat products including PAHs, the author found BaP, BaA, CHR and PAH4 in concentration of 1.74, 1.83, 0.83 and 4.4 μg\kg, while BbF was not detected in the examined smoked meat products from Assiut City, Egypt; Eldaly et al. (2016) (BaA, BaP and CHR were 16.8, 9.2 and 18.6 μg\kg in kabab samples, while were 33.2, 26.0 for BaA and BaP in kofta samples collected from Zagazig city, Egypt, respectively); Farhadian et al. (2012) (4.46 and 1.51 μg\kg for BaP and BbF in the examined, processed meat products, respectively) and Jahurul et al. (2013) who detected BaP and BbF in the beef stay by mean values of 8.34 and 6.98 μg\kg, respectively.

The variations between different authors may be attributed to variation in collection localities, smoking and processing techniques, types of the examined samples and time of exposure.

CONCLUSION

Finally, grilled beef products demonstrated a substantial risk of human PAH exposure and its negative consequences. Pan-grilled foods had lower PAH levels than charcoal-grilled foods, making it a safer processing method. Reduce the use of charcoal grills and the consumption of grilled meat products, and develop safer smoking procedures are highly recommended.

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CONFLICT OF INTEREST

The authors state that the publishing of this paper does not include any conflicts of interest.

AUTHOR'S CONTRIBUTION

REH collected samples from different markets and restaurants, performed the practical part of the research, including sample preparation and GC-MS assay; performed the required statistical tests and typed them in tables, typed the manuscript in this form, and uploaded and followed-up the research publication. RRS and ZHE developed the research plan, and supervised its implementation. All the entire authors reviewed the research before publication.

REFERENCES

Arkkelin D (2014). Using SPSS to Understand Research and Data Analysis. Psychol. Curricul. Mat. 2014; 1. https://scholar.valpo.edu/psych_oer/1

Barakat H (2021). Detection of some carcinogenic compounds in meat products and study improvement of some natural and safe preservatives using nanotechnology. Ph.D. Thesis of Vet. Med. (Food Hygiene), Assiut Univ., Egypt.

Chantara S, Sangchan W (2009). Sensitive analytical method for particle- bond polycyclic aromatic hydrocarbon. A case study in Chiang Mai, Thailand. J. Sci. Asia., 35: 32-48.

Cheng T., Chaousis S., Kodagoda G.S.M, Lam A.K., Gopalan V (2021). Polycyclic aromatic hydrocarbons detected in processed meats cause genetic changes in colorectal cancers. Int. J. Mol. Sci., 22: 10959. https://doi.org/10.3390/ijms222010959

Commission Regulation (EU) (2020). Regards Maximum Levels for Polycyclic Aromatic Hydrocarbons in Foodstuff. no. 835/2011, Official J. European Union, 2011; Ammend.; 20(8): 4-8.

Eldaly E.A., Mohamed A.H., El-Gaml A., El-hefny D.E., Mishref M.A (2016). Polycyclic aromatic hydrocarbons (PAHs) in charcoal grilled meat (Kebab) and Kofta and the effect of marinating on their existence. Zagazig Vet. J., 44(1): 40-47. https://doi.org/10.21608/zvjz.2016.7830

Farhadian A., Jinap S., Faridah A., Zaidul I.S.M (2012). Effects of marinating on the formation of polycyclic aromatic hydrocarbons (benzo[a]pyrene, benzo[b]fluoranthene and fluoranthene) in grilled beef meat. Food Control., 28: 420-425. https://doi.org/10.1016/j.foodcont.2012.04.034

IARC (International Agency for the Research on Cancer) (2012). Chemical Agents and Related Occupations in IARC Monographs on the Evaluation of Carcinogenic Risks to Humans., IARC: Lyon.

IARC (International Agency for the Research on Cancer) (2015). International agency for research on cancer monographs: evaluate consumption of red meat and processed meat. 114: Lyon, France. Press release N°. [http://www.iarc.fr/en/media-centre/iarcnews/pdf/Monographs-Q&A _Vol114.pdf].

Jahurul M.H.A., Jinap S., Zaidul I.S.M., Sahena F., Farhadian A., Hajeb P (2013). Determination of fluoranthene, benzo[b]fluoranthene and benzo[a]pyrene in meat and fish products and their intake by Malaysian. Food BioSci., 1: 73-80. https://doi.org/10.1016/j.fbio.2013.03.006

Jira W., Pöhlmann M., Hitzel A., Schwägele F (2013). Smoked meat products - innovative strategies for reduction of polycyclic aromatic hydrocarbons by optimization of the smoking process. Int. 57th Meat Industry Conference, Belgrade, Serbia., 24-32.

Lawal A.T (2017). Polycyclic aromatic hydrocarbons. A review, Cogent Environ. Sci. 3:1, 1339841, https://doi.org/10.1080/23311843.2017.1339841

Lee J., Su-Yeon K., Jung-Sik M., Sheen-Hee K., Dong-Hyun K., Hae-Jung Y (2016). Effects of grilling procedures on levels of polycyclic aromatic hydrocarbons in grilled meats. Food Chem., 199: 632-638. https://doi.org/10.1016/j.foodchem.2015.12.017

National Cancer Institute. (2010). Cancer trends progress report: red meat consumption. Available at: http://progressreport.cancer.gov/prevention/red_meat (accessed at 7 March 2022).

Oz E (2020). Effects of smoke flavoring using different wood chips and barbecuing on the formation of polycyclic aromatic hydrocarbons and heterocyclic aromatic amines in salmon fillets. PLoS One. 15(1):e0227508. https://doi.org/10.1371/journal.pone.0227508. PMID: 31935242; PMCID: PMC6959562.

Sampaio G.R., Guizellini G.M., da Silva S.A., de Almeida A.P., Pinaffi-Langley A.C.C., Rogero M.M., de Camargo A.C., Torres E.A (2021). Polycyclic aromatic hydrocarbons in foods: Biological effects, legislation, occurrence, analytical methods, and strategies to reduce their formation. Int. J. Mol. Sci., 22: 6010. https://doi.org/10.3390/ijms22116010

Simko P (2002). Determination of polycyclic aromatic hydrocarbons in smoked meat products and smoke flavoring food additives. J. Chromatography., 770: 3-18. https://doi.org/10.1016/S0378-4347(01)00438-8

Stumpe V., Bartkevics V., Kukare A., Morozovs A (2008). Polycyclic aromatic hydrocarbons in meat smoked with different types of wood. Food Chem., 110: 794-97. https://doi.org/10.1016/j.foodchem.2008.03.004

Ursachi C., Perta-Cris S., Munteanu F (2020). Strategies to improve meat products' quality. Foods., 9(12): 1-22. https://doi.org/10.3390/foods9121883

You W., Henneberg R., Saniotis A., Ge Y., Henneberg M (2022). Total meat intake is associated with life expectancy: A cross-sectional data analysis of 175 contemporary populations. Int. J. Gen. Med., 15: 1833–51. https://doi.org/10.2147/IJGM.S333004