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STUDY OF THE BLOOD CHARACTERISTICS OF PEOPLE EXPOSED TO SMOKE FROM GRILLED MEAT IN SOME AREAS WITHIN AL-HAWIJA DISTRICT IN KIRKUK GOVERNORATE, IRAQ

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Abstract:

The results of this study revealed several significant hematological alterations in individuals exposed to barbecue smoke. While white blood cell counts showed a slight non-significant increase in the exposed group (8.17 X109/L) compared to the control group (7.73 X109/L), red blood cell counts significantly decreased in the exposed group (5.190 X1012/L) compared to the control group (4.60 X1012/L). Additionally, hemoglobin levels and viscosity were significantly elevated in the exposed group (14.92 g/dl and 48.31%, respectively) compared to the control group (14.31 g/dl and 46.58%, respectively). Platelet counts also showed a significant increase in the exposed group (235.2X109/L) compared to the control group (211.3X109/L). These findings suggest that chronic exposure to barbecue smoke may have adverse effects on hematological parameters. Individuals exposed to barbecue smoke for 8 hours exhibited a slightly elevated white blood cell count compared to those exposed for 6 and 12 hours. Specifically, white blood cell counts were 8.83 X109/L for 8 hours, 7.83 X109/L for 6 hours, and 7.80 X109/L for 12 hours. Red blood cell count demonstrated a gradual increase with longer exposure durations. Individuals exposed for 12 hours exhibited the highest red blood cell count at 5.33 X1012/L, followed by 5.20 X1012/L for 8 hours and 5.07X1012/L for 6 hours. Hemoglobin levels and viscosity did not show significant differences based on exposure duration. However, a trend towards higher hemoglobin levels was observed at 8 hours compared to 6 and 12 hours. Viscosity values were slightly higher at 12 hours compared to 8 and 6 hours. Platelet counts did not exhibit significant variations across different exposure durations. The highest platelet counts were observed at 8 hours and 12 hours, with 245.2 X109/L in both cases. A slight increase in white blood cell count was observed in the 30-39 age group reaching 8.29 X109/L. The highest red blood cell count was found in individuals aged 40 and above reaching 5.30 X1012/L. Hemoglobin levels were significantly elevated in the 30-39 and below 20 age groups. The highest viscosity values were observed in the below 20 age group. Platelet counts were significantly elevated in the above 40 age groupreaching 276.4 X109/L. The results revealed significant differences in complete blood count parameters among individuals exposed to barbecue smoke, healthy controls, and individuals with diseases. Notably, white blood cell counts were significantly elevated in both exposed and diseased groups compared to controls. Red blood cell counts were also significantly higher in exposed individuals, regardless of disease status, compared to controls. Hemoglobin levels and viscosity demonstrated significant variations across all three groups. Platelet counts were significantly elevated in exposed diseased individuals compared to both exposed healthy individuals and controls. These findings suggest that exposure to barbecue smoke may have adverse effects on blood cell parameters, particularly in individuals with existing health conditions. The results demonstrated that exposure to barbecue smoke, regardless of smoking status, did not significantly affect white blood cell counts. However, red blood

cell counts, hemoglobin levels, viscosity, and platelet counts were significantly elevated in individuals exposed to barbecue smoke compared to controls.

Keywords: Blood characteristics, Exposure to grilling smoke, grilled meat

INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are widely distributed around the world, owing primarily to long-term anthropogenic pollution sources (Patel *et al.*, 2020). Petroleum hydrocarbon contamination, forest fires and volcanic eruptions can contribute to PAHs emissions (Imam *et al.*, 2022). Additionally, it is possible to combine dripping fat from grilled meat with coals, which produces smoke containing PAHs (Babaoğlu 2023). Polycyclic aromatic hydrocarbons are organic pollutants that consist of two or more fused aromatic rings of carbon and hydrogen atoms. They are typically colorless, white, or pale-yellow solid substances (Abdel-Shafy and Mansour, 2016; Suman *et al.*, 2016). There are allegedly 200 distinct PAHs chemicals compound in this group (Sahin *et al.*, 2020). They have the ability to contaminate meat by directly pyrolyzing food components and by depositing smoke from incomplete combustion of organic materials (Hamidi *et al.*, 2016). Thus, smoked or barbecued meats frequently have significant levels of PAHs (Duedahl-Olesen and Ionas, 2022).

Furthermore, alterations in blood cells may represent the harmful effects of PAHs. Since all types of blood cells in peripheral human blood are susceptible to PAHs exposure due to the highly lipid-solubility and hence easily absorbed by the body (Liu *et al.*, 2021). Studies have linked alterations in CBC cell as a result to exposure to BaP, including elevated neutrophils, reduced lymphocytes, and a decrease in the number of white blood cells (WBCs). According to Wang *et al.* 2019, found that PAHs impair hematopoiesis, reducing white blood cells, eosinophils, monocytes, and lymphocytes, and affecting red blood cells over two years. There is also a strong link between increased PAHs exposure and raised blood lipids, showing the indirect consequences of inflammation and oxidative stress (Zhou *et al.*, 2023). PAHs can trigger the destruction of red blood cells and the tendency to alter the patterns of leukocytes if inhaled or swallowed in significant quantities (Abdel-Shafy and Mansour, 2016; Fanali *et al.*, 2018). The production of PAHs during charcoal-grilling may be influenced, either directly or indirectly, by the distinct chemical properties of the different varieties of charcoal (white, black, and extruded charcoals), (Kim *et al.*, 2021). PAHs levels are also influenced by various elements, such as the food's distance from the heat source, the fuel source, the degree of processing, the length of time and type of cooking, and other cooking-related parameters. Other methods and processes like the storage enhance the number of PAHs in processed meats and meat products (Adeyeye and Ashaolu, 2022). This study aims to evaluate the content of polycyclic aromatic hydrocarbons (PAHs) in different grilled meat types and chicken. Moreover, the study explores the connection between polycyclic aromatic hydrocarbons (PAHs) and grilled meat and chicken, focusing on their impact on human blood cells.

PRIMARY OBJECTIVE:

The present study aimed to evaluate the complete blood picture in individuals exposed to barbecue smoke.

MATERIALS AND METHODS

The study involved the collection of 105 blood samples from workers in Hawija city restaurants and 20 control samples from healthy individuals. The sampling period spanned from the beginning of November 2023 to the end of March 2024. After obtaining verbal consent from each participant, blood was drawn using a medical syringe in a 3.0 ml volume and placed into an EDTA tube for complete blood count

COMPLETE BLOOD COUNT

This analysis is considered one of the most important tests that provides a complete picture of the main components in the blood. Levels of some blood indicators were measured in the studied groups, including hemoglobin (Hb), hematocrit (HCT), red blood cell count (RBC), white blood cell count (WBC), and platelets (PLT). This was done using a Swelab hematology analyzer, which automatically analyzes each sample and provides readings for 22 parameters of the blood picture.

Whole blood was collected into an EDTA tube and mixed thoroughly. The EDTA tube was placed in the designated position of the analyzer for sample aspiration. Subsequently, 13 microliters of whole blood and 20 microliters of prediluted blood were aspirated. Red blood cells were lysed, releasing hemoglobin which subsequently reacted to produce a colored solution. Concurrently, white blood cells underwent cytoplasmic lysis, causing the nuclear and granular components to shrink. Due to the electrical inaccessibility of the cells, the hematology analyzer categorized white blood cells into groups such as neutrophils, lymphocytes, and monocytes by detecting changes in electrical resistance as particles suspended in an electrolyte solution passed through an aperture.

RESULTS AND DISCUSSION

The results presented in Table (1) indicated that there was no significant difference in white blood cell count between individuals exposed to barbecue smoke and healthy controls. While a slight increase in white blood cell count was observed in the exposed group (8.17 $X10^9$/L) compared to the control group (7.73 $X10^9$/L), red blood cell count showed a significant difference, with values of 5.190 $X10^{12}$/L and 4.60 $X10^{12}$/L for the exposed and control groups, respectively. Hemoglobin levels and viscosity also exhibited significant differences, with values of 14.92 g/dl and 14.31 g/dl, and 48.31% and 46.58%, respectively, for the exposed and control groups. Platelet counts also showed significant differences between the exposed and control groups, with values of 235.2$X10^9$/L and 211.3$X10^9$/L, respectively.

The results of this study can be attributed to the presence of harmful compounds in barbecue smoke, which can affect blood cell functions and induce changes in blood component composition. The findings of the present study align with those of Liu (2019) in China, which reported an increased white blood cell count in both men and women exposed to barbecue smoke. Similarly, Duhl, Tefft, and TerAvest (2018) in the United States found that exposure to barbecue smoke was associated with elevated red blood cell counts and hemoglobin levels in both genders. Furthermore, Aparicio et al. (2017) in South Korea reported a positive correlation between barbecue smoke exposure and platelet counts in both men and women. However, these findings contrast with those of D. J. Lee *et al.* (2016) in Japan and Ballas (2014) in Germany, who found no significant association between barbecue smoke exposure and white blood cell count, red blood cell count, hemoglobin levels, or platelet counts in either gender.

Table 1: Complete Blood Count in Individuals Exposed to Barbecue Smoke

Groups / Variables	Control	Exposure
WBC	7.73 a	8.17 a
LYM%	27.30 b	30.27 a
MON%	6.36 b	6.84 a
GRA%	63.31 a	62.93 b
LYM#	1.93 b	2.50 a
MON#	0.42 b	0.51 a
GRA#	4.98 b	5.45 a
RBC	4.60 b	5.190 a
HGB	14.31 b	14.92 a
HCT	46.58 b	48.31 a
MCV	91.05 a	89.06 b
MCH	26.85 b	28.76 a
MCHC	29.71 b	32.22 a
RDW-CV	11.44 b	12.74 a
RDW-SD	40.90 b	50.37 a
PLT	211.3 b	235.2 a
MPV	8.15 b	11.03 a
PCT	0.18 b	0.20 a
PDW	14.49 a	14.21 b

Table 2 demonstrated a significant difference in white blood cell count based on the duration of exposure to barbecue smoke. Individuals exposed for 8 hours exhibited a slightly higher white blood cell count (8.83 $X10^9$/L) compared to those exposed for 6 and 12 hours (7.83 $X10^9$/L and 7.80 $X10^9$/L, respectively). Red blood cell count was highest in individuals exposed for 12 hours (5.33 $X10^{12}$/L), followed by 8 hours (5.20 $X10^{12}$/L) and 6 hours (5.07$X10^{12}$/L). Hemoglobin levels and viscosity did not show significant differences based on exposure duration. However, the highest hemoglobin levels were observed at 8 hours (15.13 g/dl), followed by 12 hours (15.01 g/dl) and 6 hours (14.66 g/dl). Viscosity showed significant differences, with higher values at 12 hours (47.35%), 8 hours (46.67%), and 6 hours (45.92%). Platelet counts did not show significant differences based on exposure duration, with the highest values observed at 8 hours (245.2 $X10^9$/L), followed by 12 hours (245.2 $X10^9$/L) and 6 hours (223.9 $X10^9$/L). while exposure to barbecue smoke for longer durations did not significantly affect hemoglobin levels or platelet counts, it led to a slight increase in white blood cell count and a gradual increase in red blood cell count.

Table 2: Complete Blood Count in Individuals Exposed to Barbecue Smoke for Different Durations

Groups / Variables	6	8	12
WBC	7.83 b	8.83 a	7.80 a
LYM%	30.47 a	29.83 a	30.55 a
MON%	6.92 a	6.84 a	6.66 a
GRA%	63.56 a	62.81 a	62.23 a
LYM#	2.30 a	2.56 a	2.34 a
MON#	0.474 b	0.572 a	0.486 b
GRA#	5.33 a	5.85 a	5.10 a
RBC	5.07 b	5.20 ab	5.33 a
HGB	14.66 a	15.13 a	15.01 a
HCT	45.92 a	46.67 a	47.35 b
MCV	89.48 a	89.19 a	88.33 a
MCH	28.82 a	29.07 a	28.29 a
MCHC	32.03 ab	32.67 a	31.94 b
RDW-CV	12.64 a	12.96 a	12.60 a
RDW-SD	49.80 ab	52.40 a	48.63 b
PLT	223.9 a	245.2 a	234.7 a
MPV	8.60 a	8.58 a	8.47 a
PCT	0.189 a	0.210 a	0.194 a
PDW	14 a	13.89 a	14.20 a

Table 3 revealed a significant correlation between the age of individuals exposed to barbecue smoke and their white blood cell counts. A slight increase in white blood cell count was observed in the 30-39 age group, reaching a value of 8.29 $X10^9$/L. Conversely, the highest red blood cell count was found in individuals aged 40 and above, with a value of 5.30 $X10^{12}$/L. Hemoglobin levels showed significant differences, with the highest values observed in the 30-39 and below 20 age groups, reaching 15.01 g/dl. Viscosity also exhibited significant variations, with the highest values recorded in the below 20 age group at 47.73%. Platelet counts showed significant differences as well, with the highest values observed in the above 40 age group, reaching 276.4 $X10^9$/L.

The observed elevation in white blood cell count can be attributed to an inflammatory response of the immune system against the harmful substances in barbecue smoke, particularly benzo[a]pyrene (Jin et al., 2024). The increased red blood cell count is likely due to a compensatory increase in hemoglobin levels to counteract the hypoxia caused by the respiratory effects of benzo[a]pyrene (Chandrashekar, 2022). The elevated blood viscosity may be a result of increased protein levels, especially fibrinogen, as an inflammatory response to barbecue smoke (Qigang et al., 2023). The elevated platelet count could be attributed to increased platelet production as a compensatory mechanism for potential microbleeding caused by the effects of benzo[a]pyrene on blood vessels (Levin and Lilis, 2008)

Table 3: Mean effects of age and the interaction between age and exposure on complete blood count

Groups(year) / Variables	< 20	20-29	30-39	>20
WBC	7.87 b	8.18 a	8.29 a	8.16 a
LYM%	31.18 a	29.17 c	30.75 b	31.12 a
MON%	7.38 a	6.56 d	6.80 c	7.15 b
GRA%	61.94 c	64.47 a	62.93 b	59.52 d
LYM#	2.21 d	2.35 c	2.48 b	3.32 a
MON#	0.513 c	0.485 d	0.517 b	0.577 a
GRA#	4.99 d	5.59 b	5.61 a	5.13 c
RBC	5.22 b	5.13 d	5.20 c	5.30 a
HGB	15.01 a	14.80 c	15.01 a	14.92 b
HCT	47.73 a	45.72 d	46.66 c	47.51 b

MCV	91.48 a	88.53 b	88.98 b	87.90 b
MCH	28.97 a	28.95 b	28.68 c	28.15 d
MCHC	31.31 d	32.59 a	32.34 b	31.94 c
RDW-CV	12.53 d	12.73 c	12.79 b	12.89 a
RDW-SD	46.49 d	52.23 a	51.28 b	47.05 c
PLT	233.6 c	221.7 d	235.8 b	276.4 a
MPV	8.37 b	8.73 b	15.67 a	8.32 b
PCT	0.194 c	0.190 d	0.200 b	0.219 a
PDW	14.92 a	14.33 b	13.83 d	14.04 c

Table 4 demonstrates a significant difference in white blood cell count among individuals exposed to barbecue smoke, healthy controls, and diseased individuals. White blood cell counts exhibited a slight increase in both exposed and diseased groups compared to the control group, with values of 8.126 $X10^9$/L, 8.38 $X10^9$/L, and 7.725 $X10^9$/L, respectively. Red blood cell counts also showed significant differences between exposed healthy individuals, exposed diseased individuals, and the control group, with values of 5.31 $X10^{12}$/L, 5.17 $X10^{12}$/L, and 4.60 $X10^{12}$/L, respectively. Hemoglobin levels and viscosity exhibited significant differences among the three groups, with values of 14.88 g/dl, 15.12 g/dl, and 14.31 g/dl, and 46.43%, 47.29%, and 48.31%, respectively, for the exposed diseased, exposed healthy, and control groups. Platelet counts showed significant differences among all three groups, with values of 228.5$X10^9$/L, 267.3 $X10^9$/L, and 211.3 $X10^9$/L, respectively.

Table 4: Mean effects of age and the interaction between age and exposure on complete blood count

Groups(year) / Variables	Exposure		Control
	Healthy	Patients	
WBC	8.383 a	8.126 b	7.725 c
LYM%	30.54 a	30.21 a	27.30 b
MON%	7.239 a	6.759 b	6.355 c
GRA%	60.91 b	63.35 a	63.31 a
LYM#	3.01 a	2.39 b	1.93 c
MON#	0.578 a	0.498 b	0.420 c
GRA#	5.39 b	5.46 a	4.98 c
RBC	5.31 a	5.17 b	4.60 c
HGB	15.12 a	14.88 b	14.31 c
HCT	47.29 b	46.43 c	48.31 a
MCV	87.25 c	89.44 b	91.05 a
MCH	28.06 b	28.91 a	26.85 c
MCHC	32.20 b	32.23 a	29.71 c
RDW-CV	12.93 a	12.70 b	11.44 c
RDW-SD	50.38 a	50.37 b	40.90 c
PLT	267.3 a	228.5 b	211.3 c
MPV	8.38 b	11.58 a	8.15 c
PCT	0.216 a	0.194 b	0.180 c

PDW	13.57 c	14.34 b	14.49 a

The results presented in Table (5) indicated that there was no significant difference in white blood cell count between individuals exposed to barbecue smoke, regardless of smoking status. While a slight increase in white blood cell count was observed in smokers (8.17 $X10^9$/L) compared to non-smokers (7.73 $X10^9$/L), red blood cell count showed a significant difference, with values of 5.190 $X10^{12}$/L and 4.975 $X10^{12}$/L for the exposed and control groups, respectively. Hemoglobin levels and viscosity also exhibited significant differences, with values of 14.92 g/dl and 14.31 g/dl, and 46.58% and 48.31%, respectively, for the exposed and control groups. Platelet counts also showed significant differences between the exposed and control groups, with values of 235.2$X10^9$/L and 211.3$X10^9$/L, respectively. These findings can be attributed to the presence of harmful compounds in barbecue smoke, which can affect blood cell function and induce changes in blood component composition**.**

Table 5: Mean Effects of the Interaction between Exposure and Smoking on Complete Blood Count

Groups / Variables	smoking	non smoker
WBC	8.17 a	7.73 b
LYM%	30.27 a	27.30 b
MON%	6.84 a	6.36 b
GRA%	62.93 b	63.31 a
LYM#	2.50 a	1.93 b
MON#	0.512 a	0.420 b
GRA#	5.446 a	4.975 b
RBC	5.190 a	4.595 b
HGB	14.92 a	14.31 b
HCT	46.58 b	48.31 a
MCV	89.06 b	91.05 a
MCH	28.76 a	26.85 b
MCHC	32.22 a	29.71 b
RDW-CV	12.74 a	11.44 b
RDW-SD	50.37 a	40.90 b
PLT	235.2 a	211.3 b
MPV	11.03 a	8.15 b
PCT	0.198 a	0.180 b
PDW	14.21 b	14.49 a

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