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Original Article

Toxicological Effects of Commonly Used Mosquito Coil Smoke on Liver and Lung Function in Rats

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Abstract

The utilization of mosquito coils as a household-level strategy for mosquito control is widely practiced in malaria-endemic regions spanning Africa, Asia, and South America. However, the continuous application of mosquito coils has prompted significant apprehensions concerning environmental and health implications. This research aims to evaluate the potential hepatic and pulmonary toxicities associated with the inhalation of mosquito coil smoke in rat subjects over both sub-chronic and chronic durations. A questionnaire was used to make inquiries regarding the prevalent types and brands of mosquito coils employed, the manner in which they are used, the durations for which they are utilized. A total of twenty-four albino rats were categorized into three distinct groups: the control group and two exposed groups. These groups were subjected to distinct brands of mosquito coil smoke across two distinct exposure regimens – a sub-chronic exposure lasting 4 weeks and a chronic exposure spanning 12 weeks. Following the exposure periods, blood samples were collected for the analysis of serum-based and biochemical markers, including serum aspartate aminotransferase (AST), alanine aminotransferase (AST), alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), bilirubin, serum bicarbonate, and Lactate dehydrogenase (LDH), oxygen saturation, C-reactive protein, total protein, and microscopic analysis of lung tissue and liver tissue. The histopathological analysis of lung tissue was appropriately included. However, the analysis of liver tissue was omitted. The results demonstrated a significant elevation in the levels of these biochemical markers among the exposed rats in comparison to the control group. Concurrently, a decrease in blood oxygen saturation was noted in the exposed rats when contrasted with the control group. Conversely, the serum concentrations of high-sensitivity C-reactive protein, total protein, and alanine aminotransferase (ALT) did not exhibit notable differences in relation to the control group. Additionally, microscopic analysis of lung tissue indicated the presence of histopathological lesions in the exposed rats, suggesting a detrimental impact of mosquito coil smoke exposure in a time-dependent progression.

Keywords: Mosquito coil smoke, Hepatic and pulmonary toxicities, Inhalation exposure, Biochemical markers, Histopathological lesions.

INTRODUCTION

Insect-borne diseases pose significant global health challenges, particularly in tropical and subtropical regions [1]. Nigeria, with the highest number of malaria cases, contributes significantly to the malaria burden in Africa [2,3]. Factors such as subtropical climate, poor drainage systems, and dense populations contribute to the increasing mosquito problem [4]. In Nigeria, various mosquito repellents, including locally-made brands, are used to combat malaria outbreaks [5,6]. However, concerns have been raised about the use of volatile organic compounds found in mosquito repellents and their impact on human health [7,8].

While mosquito coils are generally considered safe for humans and mammals, using them in closed rooms raises concerns. Burning one mosquito coil can release particulate matter and emit formaldehyde equivalent to burning a significant number of cigarettes [9,10]. This can lead to various health issues such as respiratory irritation, coughing, sneezing, and renal damage [11–14].

Mosquito coils find widespread use, particularly in sleeping quarters during nighttime, resulting in heightened levels of exposure. The emissions from these coils encompass minute particles, metallic emanations, and vaporous compounds that have the potential to provoke irritation within the respiratory tract . Mainly composed of pyrethrum powder, mosquito coils are extensively employed within economically disadvantaged populations in Asia, Africa, and South America due to their cost-effectiveness [15]. It is noteworthy, however, that the combustion of a single mosquito coil can discharge particulate matter and formaldehyde at levels akin to a considerable quantity of cigarettes [10,11].

The pivotal component of mosquito coils, allethrin, functions as a pyrethroid insecticide [16,17]. The emissions and insecticidal agents emanating from smoldering mosquito coils principally serve the purpose of repelling mosquitoes [17]. Investigations into rats subjected to pyrethroid insecticides have manifested alterations in specific blood indicators, albeit without significant impact on white blood cell counts [18]. Prolonged exposure to smoke from mosquito coils has been associated with the occurrence of asthma and persistent wheezing in children [19–21].

Toxicological examinations performed on animals exposed to mosquito coil emissions have unveiled an array of health consequences, encompassing harm to the respiratory system, kidneys, and spleen [22–24]. Rats subjected to mosquito smoke have displayed escalated levels of urea and creatinine, accompanied by elevated white blood cell counts [7,25]. Furthermore, the fumes emitted by mosquito coils have been observed to induce chromosomal irregularities within both exposed rats and mice [10,13].

The combustion products of mosquito coils, including sub-micron particles coated with heavy metals, allethrin, and vapors such as phenol, benzene, and toluene, contribute to their toxicity nazdwork [25–27] .

However, the continuous and widespread use of mosquito coils, particularly in closed indoor spaces, poses health risks due to the inhalation of toxic compounds [28]. Children exposed to mosquito coil smoke have shown respiratory problems like asthma and persistent wheezing [21]. Additionally, epidemiological studies have demonstrated mutagenic effects and morphological changes in animals exposed to mosquito coil smoke [3,22,23,].

The present study was undertaken to evaluate the repercussions of sustained and prolonged exposure to mosquito coil smoke on indicators of liver and lung function in Wister albino rats. The overarching objective was to establish a comprehensive grasp of the potential risks entailed in human exposure to these pesticides, utilizing Wister albino rats as a model organism for assessment.

MATERIALS and METHODS

Questionnaire

Data collection was facilitated through the utilization of a well-organized questionnaire. The questionnaire encompassed inquiries regarding the prevalent types and brands of mosquito coils employed, the manner in which they are employed, the durations for which they are utilized, as well as the observed effects subsequent to exposure. Specifically, the random systematic sampling technique was implemented, which involved the systematic selection of 200 adult individuals from residential zones within the Gwale Local Government Area (LGA) of Kano state.

Experimental Animals

The experimental cohort comprised a total of twenty-four (24) adult albino rats from the Wister strain, with body weights falling within the range of 200–250 g. These rats were procured from the animal facility center located at the National Veterinary Research Institute in Vom, Plateau State, Nigeria. Subsequently, the rats were housed within plastic cages, maintaining an ambient temperature consistent with room condition (24±2°C). This period of housing allowed for a two-week acclimatization process, during which the rats were subjected to the natural diurnal and nocturnal atmospheric patterns characteristic of the Savannah region in Kano state, Nigeria. Nutritional needs were met by providing the rats with unrestricted access to laboratory animal feed and water. For the experimental protocol, the rats were partitioned into cages and subjected to exposure to smoke generated by mosquito coils. The methods employed for this exposure mirrored the practices commonly observed among the general population.

Collection / Compositions of sample

The acquisition of mosquito coils was carried out through purchases made at several retail establishments situated within the Gwale Local Government Area (LGA) in Kano, Nigeria. The selected brands for experimental purposes were commercially available variants that comprised pyrethroids, specifically d-trans-allethrin, at a concentration of 0.2%w/w, alongside an inert ingredient constituting 99.8%w/w. The physical attributes of the mosquito coil employed in the study were gauged, revealing dimensions of 12 cm in diameter, 85 cm in length, and an overall weight of 14.0 grams.

In the course of the experiment, two distinct brands, namely Boxer and Super Kill, were chosen as representatives. The selection of these brands was informed by their prevalence and widespread use within the study area, adding a layer of relevance and authenticity to the experimental conditions.

Experimental Grouping of Animals

Research on experimental animals was conducted in accordance with the internationally accepted principles for laboratory animal use and care. In addition, the protocol of animal study was based on the guidelines given by the Law of Animal Protection Act of Bayero University Kano, Nigeria with approval number BUK/CHS/REC/113.

Twenty-four rats were assigned to three groups, each consisting of eight rats. Group I functioned as the control and remained unexposed to mosquito coil smoke. Group II and Group III were exposed to smoke from Boxer and Super Kill mosquito coils, respectively, for a duration of six hours daily over a four-week period. After this initial exposure, half of the rats in each were sacrificed, while the remaining rats underwent an additional eight weeks of continuous smoke exposure.

After 24hr of treatment, the animals in each group were anesthetized and humanely euthanized through cervical dislocation. The intact lung and liver tissues were rapidly excised through surgical means and promptly immersed in a solution of 10% normal saline to preserve their structural integrity for further histological examination.

Blood samples were extracted from the tail veins of the rats using a direct needle insertion into the tail blood vessel, and the collected blood was drawn into a syringe with a needle. The collected blood was allowed to stand for thirty minutes before undergoing centrifugation at 5000 rpm for ten minutes at a temperature of 4°C. This centrifugation process separated the serum, which was collected as a clear supernatant and stored at -20°C for subsequent biochemical analysis.

Biochemical estimation of serum

Various biochemical parameters were determined in the experiment. Gamma-glutamyl transferase (GGT) activity was assessed using the modified Szasz method [29] by Steinmett et al. [30], measuring the absorbance at 405 nm. Alanine aminotransferase (ALT), Alkaline phosphatase (ALP) and aspartate aminotransferase (AST) activities and total protein were determined following the Talib and Khurana method [31] by monitoring the absorbance at 546 nm.) with colorimetric detection. Total bilirubin levels were determined based on the Jendrassik and Grof method using a reaction with diazotized sulphanilic acid [32].

Albumin concentration was assayed according to the Bradford method [33], Serum bicarbonate (HCO_3) levels were determined [34], and high-sensitive C-reactive protein (hs-CRP) was measured using the Roberts et al. method with fluorescence intensity readings [35]. Lactate dehydrogenase (LDH) activity was determined via the Roche method, and oxygen partial pressure was assessed using pulse oximetry following the Jubran method [36,37].

Histopathological Examination of Liver and Lung

The liver and lung biopsies from albino rats were fixed in 10% normal saline and then transferred to a specially designed cassette. The tissues were dehydrated using increasing concentrations of alcohol, followed by clearing with toluene. Subsequently, the tissues were infiltrated with molten paraffin wax, replacing the water and making them compatible with paraffin. This process, known as tissue processing, prepared the tissues for further examination.

The resulting tissue blocks were sliced tissues were cut into 4-µm thickness and stained with hematoxylin and eosin using a microtome, creating thin sections suitable for microscopic analysis. These sections were then stained using hematoxylin and Epson staining technique. Examination of the stained sections was performed using a Leica Dm 750 microscope, and images were captured using a Leica ICC 50HD Camera [38,39].

Data Analysis

The data obtained from the experiments were expressed as mean ± standard deviation and were subjected to a One-way Analysis of Variance (ANOVA) and Tukey's post hoc test. The data were considered statistically significant at $p < 0.05$ using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Response to Questionnaires

Table 1 presents the responses regarding the usage of different brands of mosquito coils in Gwale L. G. A. of Kano state. The total number of respondents in the survey was 200. From the table, it can be observed that Boxer and Super Kill were the most commonly used brands, with frequencies of 78 and 75 respectively, accounting for 39.00% and 37.50% of the respondents. Rambo, Wave Tide, and Split had lower frequencies and percentages, indicating relatively lower usage among the respondents.

Table 1. Response on Common Brand of Mosquito Coil used In Gwale L. G. A. Kano state

Mosquito coil brand	Frequency	Percentage respondent (%)
Boxer	78	39.00
Super kill	75	37.50
Rambo	20	10.00
Wave tide	23	11.50
Split	4	2.00
Total	**200**	**100**

Table 2 presents the data on the mode of use of mosquito coils in Gwale L. G. A., Kano state. From the table, it can be observed that the most common mode of use was "Doors and windows close," with a frequency of 118, accounting for 60% of the respondents. The second most common mode was "Doors closed; windows open," with a frequency of 56, representing 29% of the respondents. "Doors and windows open" had a lower frequency of 16, making up 8% of the respondents. The least common mode was "Doors and windows open with the fan on," with a frequency of 6, accounting for 3% of the respondents. Overall, the table provides an overview of the different modes of use adopted by respondents when using mosquito coils in Gwale L. G. A., Kano state.

Table 2. Mode of use of mosquito coil in Gwale L. G. A., Kano state

Mode of use	Frequency	Percentage (%)
Doors and windows close	118	60
Doors closed; windows open	56	29
Doors and windows open	16	8
Doors and windows open with the fan on	6	3
Total	**200**	**100**

Table 3 presents data on the duration of use of mosquito coils in Gwale L. G. A., Kano state. From the table, it can be observed that the most common duration of use was in the range of "4-6 hours," with a frequency of 136, accounting for 69% of the respondents. The next most frequent duration was "7-9 hours," with a frequency of 52, representing 27% of the respondents. The range of "1-3 hours" had a low frequency of 2, making up 1% of the respondents. The range of "10-12 hours" had the lowest frequency of 6, accounting for 3% of the respondents.

Table 3. Duration of use of mosquito coil in Gwale L. G. A., Kano state

Time (hours)	Frequency	Percentage (%)
1-3	2	1
4-6	136	69
7-9	52	27
10-12	6	3

The effect of mosquito coil smoke on liver function indices after Sub-chronic exposures

Table 4 displays the impact of inhaling mosquito coil smoke on liver function following Sub-chronic exposure. Notably, the activities of ALP and ALT demonstrated a statistically significant increase ($p<0.05$) in the group subjected to boxer mosquito coil smoke compared to the control rats. Conversely, concentrations of total protein and GGT activities exhibited no substantial variation among the exposed groups in comparison to the control group. Furthermore, concentrations of total bilirubin experienced a significant rise ($p<0.05$) in the rat groups exposed to super kill mosquito coil smoke relative to the control group.

Table 4. Effect of Sub-chronic exposure to selected mosquito coils smoke on liver function indices in rats

Treatments	AST (IU/L)	ALT (IU/L)	ALP (IU/L)	GGT activity (U/L)	Total Protein (g/L)	Total Bilurbin (g/L)	Albumin (g/L)
Control (not exposed to any coil)	15.25±2.87	3.50±0.58	34.00±9.07	15.02±0.42	132.18±12.53	0.03±0.0129	23.45±2.92
Boxer coil	16.75±2.87	6.00±2.31	60.62±18.57*	16.58±7.68	127.25±14.43	0.06 ± 0.01	22.50±2.63
Super Kill coil	20.75±5.19	4.50±0.58	36.50 ±1.27	15.15±2.30	130.90±0.52	0.41 ± 0.14*	23.10±3.45

Data are expressed as mean ± standard deviation of triplicate determinations. Values with superscript (*) within similar columns indicate significant differences at $p<0.05$.

AST (aspartate aminotransferase); ALT (alanine aminotransferase); ALP (alkaline phosphatase); GGT (gamma-glutamyl transferase).

The effect of mosquito coil smoke on lung function indices after Sub-chronic exposures

The effects of mosquito coil smoke inhalation on lung function after sub-chronic exposure are presented in Table 5. CO_2 concentration showed a significant ($p<0.05$) increase in all groups of rats exposed to mosquito coil smoke when compared with control rats. There is a significant decrease in oxygen saturation in all the coils treated groups when compared with the control group. LDH activities were significantly ($p<0.05$) increased in the group of rats exposed to boxer mosquito coils smoke when compared with the control group. C reactive protein activities were insignificant.

Table 5. Effect of sub-chronic exposure to selected mosquito coil smoke on lung function indices in rats.

Treatments	Bicarbonate mmol/L	Blood oxygen concentration (%)	High Sensitive C-Reactive Protein (mg/L)	Lactate Dehydrogenase (U/L)
Control	20.65 ± 0.79	91.25 ± 6.29	1.0 ± 0.01	70.88 ± 6.25
Super Kill coil	24.00 ± 0.12*	67.25 ± 5.71*	0.66 ± 0.02	77.00 ± 15.50
Boxer coil	25.80 ± 2.68*	60.50 ± 15.72*	0.851 ± 0.04	141.75 ± 7.22*

Data are expressed as mean ± standard deviation of triplicate determinations. Values with superscript (*) within similar columns indicate significant differences at $p<0.05$.

The effect of mosquito coil smoke on liver function indices after chronic exposure

The effects of mosquito coil smoke inhalation on the liver after chronic exposure are presented in Table 6. GGT and AST activities were significantly increased GGT(17.35 and 20.84) AST(51.75 and 54.25IU/L) in all coiled treated groups when compared with the control (10.71 IU/L). ALP activity was significantly ($p<0.05$) increased in the group of rats exposed to boxer mosquito coli smoke when compared with the control group. Total bilirubin concentration shows a significant

($p<0.05$) increase in all groups exposed to the mosquito coil smoke when compared with control rats. No significant increase in ALT activities, total protein, and albumin concentrations was observed.

Table 6. Effect of chronic exposure to selected mosquito coil smoke on liver function indices in rats.

Treatments	AST (IU/L)	ALT (IU/L)	ALP (IU/L)	Gamma Gt activity (U/L)	Total Protein (g/L)	Total Bilurbin (g/L)	Albumin (g/L)
Control	30.75 ± 0.96	23.00±0.41	60.50±2.40	10.71±0.58	81.11±1.00	0.08±0.00	43.22±2.55
Boxer coil	51.75±24.94*	23.75±2.99	74.05±29.89*	17.35±5.66*	79.02±1.37	0.11±0.01*	31.80±21.07
Super Kill coil	54.25±5.85*	23.75±3.30	61.48±3.75	20.84±2.00*	80.45±3.88	0.17±0.06*	41.40±3.32

Data are expressed as mean ± standard deviation of triplicate determinations. Values with superscript (*) within similar column indicate significant difference at $p<0.05$.

The effect of mosquito coil smoke on lung function indices after chronic exposure

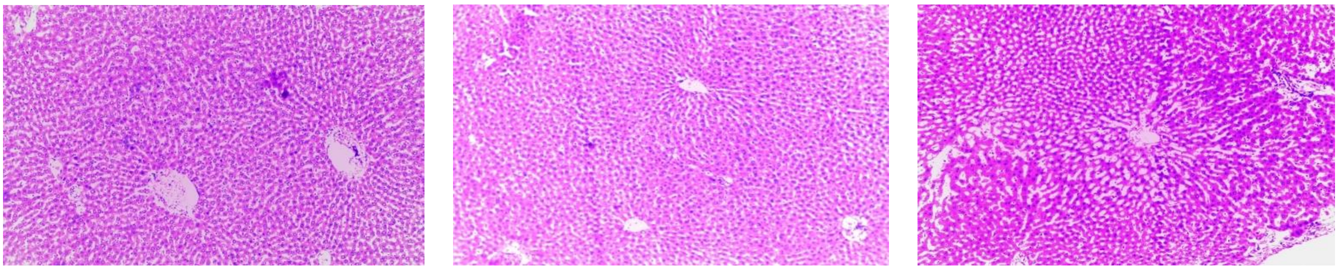
The effect of mosquito coil smoke inhalation on lung function indices after chronic exposure are presented in Table 5. Lactate dehydrogenase activities hi concentration were significantly increased (219.12U/L and 144.62U/L) in all groups of rats exposed to mosquito coil smoke when compared with control (98.50U/L). Oxygen saturation showed significant decrease in all groups of rats exposed to mosquito coil smoke when compared with control.

Table 7. Effect of chronic exposure to selected mosquito coil smoke on lung function indices in rats.

Treatments	Bicarbonate mmol/L	Blood oxygen concentration (%)	High Sensitive C-Reactive Protein (mg/L)	Lactate Dehydrogenase (U/L)
Control	10.40±0.16	91.00±2.31	1.42± 0.01	98.50±52.33
Boxer	25.08±2.24*	51.50±4.73*	0.88± 0.61	210.12 ±7.05*
Super Kill	27.17 ±2.92*	52.00±5.48a*	0.62± 0.11	144.62±76.79*

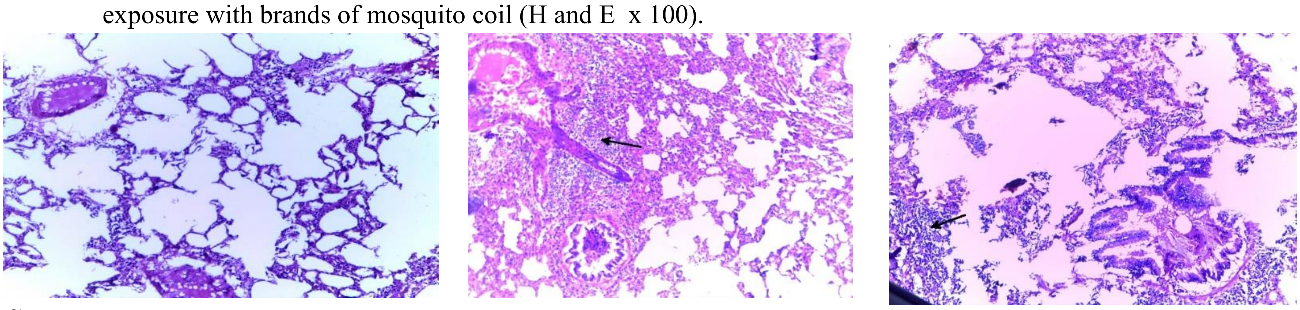
Data are expressed as mean ± standard deviation of triplicate determinations. Values with superscript (*) within similar columns indicate significant differences at $p<0.05$.

Histopathological studies



Control **Boxer** **Super kill**

Figure 1. Histopathological photomicrograph of liver tissues showing an intact liver tissues (no changes) on sub-chronic (4 weeks) exposure with brands of mosquito coil (H and E x 100).



Control **Boxer** **Super kill**

Figure 2. Histopathological photomicrograph of lung tissues, the black arrows showing areas of inflammation on sub-chronic exposure with different brand mosquito coil (H and E x 100)

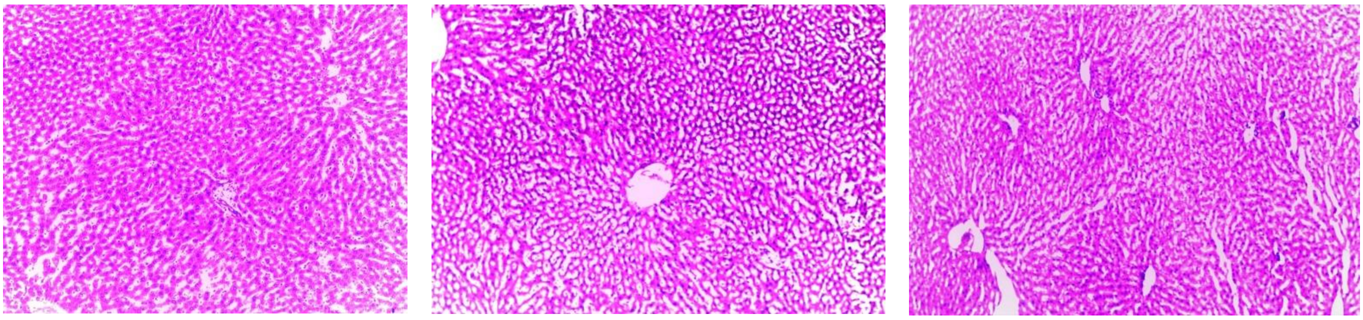


Figure 3. Histopathological photomicrograph of liver tissues showing an intact liver tissues on chronic exposure with different brand mosquito coil (H and E x 100).

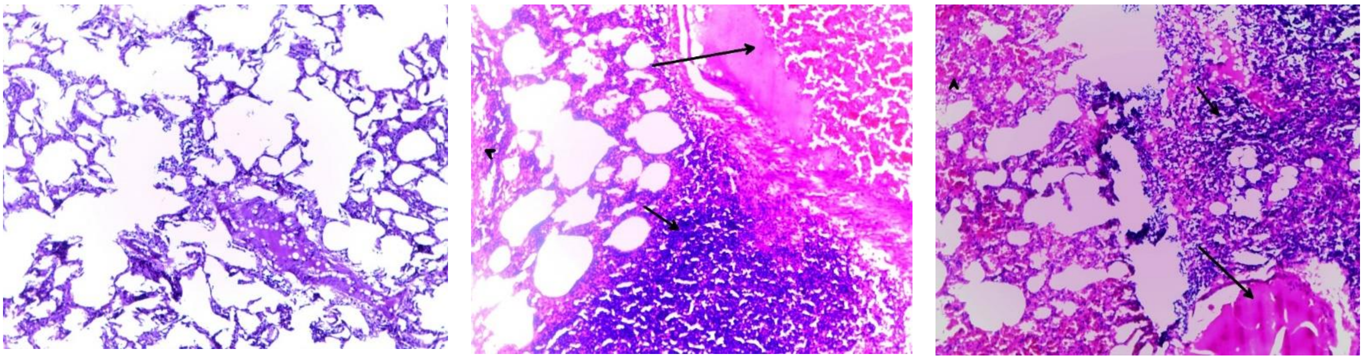


Figure 4. Histopathological photomicrograph of lung tissues, the black arrows showing areas of inflammation on chronic exposure to different brand mosquito coil (H and E x 100)

DISCUSSION

The liver conjugate bilirubin with glucuronic acid, forming a soluble compound. This conjugated bilirubin then proceeds through the bile duct before being expelled into the gastrointestinal tract. Concurrently, an albumin-bound, unconjugated bilirubin variant circulates within the bloodstream. This unconjugated form, being insoluble, typically remains excluded from renal filtration into the urine. High leves of bilirubin (Table 6) indicate that bile is not being properly excreted, therefore an obstruction may be present in the duct or gallbladder.

However, the outcomes of the experimental investigation subsequent to sub-chronic exposure, particularly with regard to liver function markers as illustrated in Table 2, indicate that in the group of rats exposed to boxer mosquito coil smoke, liver enzymes such as alkaline phosphatase (ALP) and total bilirubin exhibited significant increases. This noteworthy shift could potentially point toward a hindrance in the bile ducts. Nevertheless, parameters including total protein, albumin, gamma-glutamyl transferase (GGT), aspartate aminotransferase (AST), and alanine aminotransferase activities did not show statistically significant alterations after sub-chronic exposure. This observation suggests that the liver might not have sustained substantial damage following the sub-chronic exposure period.

Additionally, the findings from the sub-chronic exposure assessment of lung function indices, as presented in Table 3, unveiled notable alterations. Serum bicarbonate levels displayed a statistically significant elevation ($p<0.05$), accompanied by a reduction in oxygen concentration among the exposed rat groups. This observation suggests an elevated presence of CO_2, leading to a decreased affinity of hemoglobin for oxygen. The implication here is that CO_2 binds to hemoglobin, potentially attributed to the heightened CO_2 content within the smoke.

Furthermore, a significant rise ($p<0.05$) in Lactate dehydrogenase (LDH) activity was discerned within the group exposed to boxer mosquito coil smoke. The increased LDH level is indicative of a toxic influence from mosquito coil smoke, which becomes more pronounced following chronic exposure. This elevated LDH level may be attributed to tissue damage, a phenomenon that can arise from various sources such as acute myocardial infarction, anemia, pulmonary embolism, hepatitis, or acute renal failure [40]. LDH emerges as a potentially valuable marker of synthetic inflammation due to its ubiquitous presence within tissue as a cytoplasmic enzyme. Notably, escalated serum LDH concentrations have been reported in cases of acute lung damage in conditions like interstitial lung disease and severe respiratory failure [41].

However, it is noteworthy that the results of this study stand in contrast to the findings of Pauluhn and Mohr [42], who suggested that mosquito coils under regular use might not pose a significant health risk. Remarkably, the activities of gamma-glutamyl transferase (GGT) and aspartate aminotransferase (AST) displayed statistically significant increments. Such elevation in enzyme activities could potentially stem from inflammation within the biliary tract, aligning with analogous outcomes reported by Abubakar and Hassan [25,43]. Elevations in GGT levels could trigger damage to red blood cell membranes, thereby releasing iron or copper, both of which can contribute to a series of potentially detrimental prooxidant reactions involving transition metals [43] [49]. Enhanced peroxidation levels, in turn, can culminate in downstream cellular, tissue, and DNA damage, driven by oxidative and nitrosative stress alongside the generation of harmful reactive oxygen species or nitric oxide (ROS or NO) [44,45].

The increase in these enzyme levels appears to be primarily due to the leakage of these enzymes from compromised hepatic cells into the bloodstream, rather than an escalated rate of biosynthesis [44,46,47]. A reduction in albumin concentration, albeit not statistically significant, hints at diminished albumin synthesis by the liver, which could potentially be a repercussion of liver injury.

Elevated bicarbonate levels in the bloodstream can indicate metabolic alkalosis, a condition that results in an increase in tissue pH. Metabolic alkalosis can emerge from the loss of acid within the body, often linked to factors like vomiting and dehydration. It can also be associated with conditions such as anorexia and chronic obstructive pulmonary disease, which might contribute to unfavorable respiratory health implications. This may stem from the accumulation of indoor carbon monoxide (CO) levels exceeding the World Health Organization's (WHO) recommended guideline of 10 mg/m3 for an 8-hour average exposure [48]. The reduction in blood oxygen concentration within the groups exposed to mosquito coil smoke could be attributed to the presence of CO. A previous study reported a mean CO concentration of 6.5 ppm following the use of mosquito coils within an enclosed indoor setting [49,50].

Histopathological examinations revealed lung tissue lesions in rats subjected to chronic exposure to coil smoke (Fig. 1 and 3). The figures illustrated instances of pulmonary fibrosis and bronchial thickening. These findings imply that prolonged exposure to mosquito coil smoke can lead to lung rigidity, impairing normal respiratory function. Likewise, other reports have linked extended use of various repellents (for at least 8-10 hours daily) to the onset of acute respiratory infections like colds, asthma, and pneumonia.[24,51–54] When a mosquito coil is burned, the insecticides evaporate with the smoke, which immobilizes the mosquito and prevents it from entering the room. The combustion of the remaining materials generates large amounts of submicrometer particles and gaseous pollutants. These submicrometer particles may reach the lower respiratory tract and be coated with a wide range of organic compounds such as polycyclic aromatic hydrocarbons. Moreover, burning one mosquito coil releases the same amount of particulate matter ($PM_{2.5}$) as burning 75-137 cigarettes. Also, the emission of formaldehyde from burning one coil can be as high as that released from burning 51 cigarettes [11,43,52,55].

No histological alterations were observed in the liver of the exposed rats. This absence of discernible damage indicates the integrity of liver tissue (Fig. 2 and 4). However, the lung and liver histological analysis of rats exposed to mosquito coil smoke suggests a greater impact on lung tissues, likely attributed to exposure to diverse toxic substances present in the coil smoke [4,25,53]

CONCLUSION

Exposure to boxer and super kill mosquito coil smoke resulted in notable changes in liver enzyme levels and lung tissue structure. This investigation highlights the detrimental impact of mosquito coil smoke on health, which arises from the emission of toxic organic compounds during indoor burning. The presence of these hazardous substances in common sources like mosquito coils underscores the significance of this issue, as it has the potential to disrupt liver enzyme levels and alter lung tissue morphology. The extent of these effects may vary based on factors such as the mode of exposure, duration, and unique characteristics of the emission source.

Conflict of Interest

The authors declare they have no conflicting interests.

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