Assiut J. Agric. Sci., 52 (4) 2021 (66-84) *ISSN: 1110-0486*
Website:www.aun.edu.eg/faculty_agriculture/journals_issues_form.php *E-mail: ajas@aun.edu.eg*

Potential Activity of Sweet Basil (*Ocimum basilicum* L.) Leaves Extracts on Phenol Induced Physiological Alterations and Hematotoxicity in Mice

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Accepted for publication on: 30 /11 /2021

Abstract

This study was designed to evaluate the influence of some sweet basil (*Ocimum basilicum* L.) leaves extracts on some growth performance indicators, physiological and hematological responses in mice orally exposed to phenol. Sixty-six male Swiss albino mice were divided equally into eleven groups. The 1st one was assigned as a control. The 2nd group was daily oral exposed to 180 mg C_6H_5OH / kg body weight for 21 days. 3rd, 4th and 5th groups were daily oral received basil leaves hexane extract (BLHE), basil leaves ethanol extract (BLEE) and basil leaves aqueous extract (BLAE) by 400 mg / kg body weight for 21 days respectively. The 6th, 7th and 8th groups were daily oral exposed to BLHE, BLEE and BLAE by 400mg / kg body weight for 21 days respectively after exposure to 180mg C_6H_5OH / kg body weight for 21 days. Finally, 9th, 10th and 11th groups were daily oral received BLHE, BLEE and BLAE by 400 mg / kg body weight for 21 days respectively before exposure to 180 mg C_6H_5OH / kg body weight for 21 days. As a response of phenol administration, the liver % reduced while the kidney %, spleen %, and testis % were increased. Hematological indicators, such as RBCs, Hb %, and PCV %, showed a significant increase. Basil leaves extracts improved some growth performance indicators, reduced phenol adverse effects on several organs and hematological parameters. These findings show that basil leaves extracts can be used as an anti-toxin agent with a wide range of health benefits.

Keywords: *Basil, mice, phenol, physiology, toxicity, growth performance.*

Introduction

Pollution is a public health and environmental concern that represents a danger worldwide. Phenol (C_6H_5OH) is one of the sources of environmental pollution which could exist and bioaccumulate at a high level in our ecosystem by natural processes or man-made activities such as mining and industrial activities (Abd Gami *et al.,* 2014). It is also called hydroxybenzene, and an organic aromatic compound consisting of a hydroxyl group attached directly to a benzene ring. It was formed in the environment by the disintegration of organic matter, coal tar, creosote and as plant secondary metabolite (Boudet, 2007). Commercially, phenol exists in needle-like colorless crystalline form which rapidly dissolve in organic solvents and water (ATSDR, 2008). Chemically, it can be formed by the oxidation of toluene and heating of monochlorobenzene at 350^0C in the presence of sodium hydroxide (Basha *et al.,* 2010).

It has been used since ancient times as an industrial chemical substance in the production of chemical intermediates, explosives, dyes, plastics, oil refining, pharmaceutical, antiseptics, aspirin, synthetic polymers, phenolic resins, reagents in chemical analysis, and leather and wood preservatives (Huang *et al.,* 2012 and Abd Gami *et al*., 2014). There are many different health hazards that can cause kidney and liver injuries (Olujimi *et al.,* 2010). Phenol chronic exposure causes hemolytic anemia, hypotension, arrhythmia, methemoglobinemia, and others. While acute exposure to phenol can lead to elevated blood pressure, gradually low blood pressure and shock (Basha *et al.,* 2010). The administration of phenol using animal models show various pathological alterations in lung, kidney, skin, liver and others due to its adverse effects (Abd Gami *et al*., 2014).

Basil or sweet basil (*Ocimum basilicum*) belongs to the family *Lamiaceae*. It has been used excessively in herbal medicine in developing and developed countries as a therapeutic agent to attenuate a broad range of diseases due to its numerous pharmacological activities (Samson *et al.,* 2007). One of the most common activities of basil plant is an antioxidant activity which principally due to its higher content of phenolic compounds such as phenolic acids, flavonoids, aromatic compounds, rosmarinic acid and others (Gülçin *et al*., 2007). In the past recent years, multiple studies have proven that basil leaves extracts have cogent anticancer (Manosroi *et al.,* 2006), antiviral (Almeida *et al.,* 2007), anti-aging (Bozin *et al.,* 2006), antimicrobial (Akujobi *et al.,* 2004) and antioxidant activities (Chiang *et al.,* 2005). Also, basil leaves extract is composed of various compounds that are able to stimulate the release of glycolproteins called thrombopoietin (Ofem *et al*., 2012) and erythropoietin (Ali *et al.,* 2017) which induce and regulate the formation and production of platelets and erythrocytes. Thus, the present study was conducted to investigate the impact of different basil leaves extracts on some physiological and hematological indices in male Swiss albino mice toxified with phenol.

Materials and Methods

Phenol reagent

The extra pure crystallin Phenol (C_6H_5OH, purity 99%) (CAS No 108-95-2) was purchased from Oxford Lab Fine Chem, Maharashtra, India. Phenol crystals were dissolved in an adequate volume of distilled water as a solvent then completed to the required volume by distilled water to perform the final concentration of 180 mg / kg body weight as determined by Monfared *et al.* (2014) then, was provided as a convenient dose for the experiments.

Plant material

Fresh basil plants were collected from the field of ornamental plants farm in the Faculty of Agriculture, Minia University. Plants were botanically authenticated and identified as a sweet basil (*Ocimum basilicum* L.) by a botanist at the horticulture department (ornamental plants branch). Basil plants were manually made free of foreign matter, debris and laundered with clean water. Leaves were manually picked from plants and dried by air drying at room tempera-

tures for about 3 weeks until constant weight at the department of agricultural chemistry on a bench surface. The dried leaves were ground into a fine powder using a mill (Braun, Germany), sieved (40 mesh) and finally stored in dark plastic bags at 25^0C for further use.

Preparation of basil leaves extracts

Basil leaves hexane extract was extracted from dry basil leaves by using the soxhlation method. Briefly, 5 gm of powdered leaves were extracted by Soxhlet extractor with 200 ml n-hexane at 69^0C for 6 hours (De Barros *et al.,* 2013). To prepare ethanolic extract powdered leaves were extracted with ethanol 80% in a Soxhlet apparatus at 78^0C for 3 hours (Yacout *et al.,* 2012). The aqueous extract was prepared by refluxing 100g of powdered leaves with 750 ml of double-distilled water for 1 hour (Sakr and Nooh, 2013). The obtained extracts were filtered using Whitman filter paper, freed from solvents, and concentrated using a rotary vacuum evaporator.

Animals and experimental protocol

Sixty-six male Swiss albino mice, (aged 8 weeks, average weight 20 ± 2 g) were obtained from Agricultural Chemistry Department, Biological Experimental Animal Lab. Minia University, Al-Minya, Egypt. Animals were allocated into eleven groups (6 animals each). The first group was designated as the control. The second group was given 180 mg C_6H_5OH / kg body weight orally every day for 21 days. The third, fourth, and fifth groups were given 400 mg / kg body weight of basil leaves hexane extract (BLHE), basil leaves ethanolic extract (BLEE), and basil leaves aqueous extract (BLAE) for 21 days. Following a 21-day exposure to 180 mg C_6H_5OH / kg body weight, the 6^{th}, 7^{th}, and 8^{th} groups were given daily oral exposure to BLHE, BLEE, and BLAE at 400mg / kg body weight. Finally, the 9th, 10th, and 11th groups were given 400 mg/kg body weight of BLHE, BLEE, and BLAE daily for 21 days before being given 180 mg C_6H_5OH/kg body weight for 21 days.

Growth performance indexes

At the start and end of the 42-day experiment, the initial and final body weights were taken. Body weight gain (BWG), average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (FE) were calculated using the following formulas: (Suyitman *et al.,* 2020).

$$\text{Body weight gain (BWG)} = \text{Final weight} - \text{initial weight}$$

$$\text{Average daily gain (ADG)} = \frac{\text{Final weight} - \text{initial weight}}{\text{Number of experimental days}}$$

$$\text{Average daily feed intake (ADFI)} = \text{Feed provided - feed remaining}$$

$$\text{Feed efficiency (FE)} = \frac{\text{Average daily gain}}{\text{Feed intake}} \times 100$$

Blood collection and hematological studies

Three mice from each group were weighed, murdered, and allowed to bleed completely after 21 and 42 days respectively. Testis, liver, kidneys, lungs, and spleen were all weighed and recorded separately. Decapitation was used to collect blood in heparinized tubes between 7:00 and 8:00 a.m., avoiding first drips. A veterinary hematology analyzer was used to measure red blood cells (RBCs), hemoglobin (Hb), packed cell volume (PCV), mean

corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), the standard deviation of red blood cell distribution width (RDW-SD), coefficient of variation of red blood cell distribution width (RDW-CV), platelets (PLT), mean platelet volume (MPV), platelet distribution width (PDW), procalcitonin (PCT), platelet large cell ratio (P-LCR), white blood cells (WBCs) count, lymphocytes (%) and neutrophils (%)

Statistical analysis

IBM SPSS Statistics version 25 software was used to conduct statistical analysis of the data, which included one-way analysis of variance (ANOVA) and Duncan's multiple comparison tests with a 95 % confidence interval of $P < 0.05$, the results of the comparison between the control and treatment groups were deemed statistically significant.

Results and Discussion

Growth performance indicators

The influence of phenol and various basil leaves extracts on the growth parameters of mice is presented in Table 1. With the exception of the last group, which received BLAE + C_6H_5OH, final weight, body weight gain, and average daily gain were increased significantly ($p < 0.05$) as a result of phenol and various basil leaves extracts. Feed intake was increased/decreased depending on the treatment. In addition, animals in control group were recorded the lowest feed efficiency (%) ($p < 0.05$) compared to other experimental groups (Table 1).

Table 1. The growth parameters of mice ingested phenol and various basil leaves extracts orally in different experimental groups.

Treatment Groups	Indices					
	Initial weight, g	Final weight, g	Body weight gain, g	Average daily gain, g	Feed intake g/day	Feed efficiency (%)
Control	22.21±0.12	34.15±0.11^{bc}	11.94±0.05^{b}	0.28±0.001^{b}	18.01±0.17^{f}	1.55 ± 0.01^{a}
C_6H_5OH	18.69±0.43	36.56±0.28^{e}	17.87±0.14^{h}	0.42±0.005^{h}	12.60±0.23^{c}	3.33 ± 0.10^{f}
BLHE	19.91±0.49	36.88±0.28^{ef}	16.97±0.20^{fg}	0.40±0.005^{fg}	19.07±0.28^{g}	2.09 ± 0.06^{b}
BLEE	21.00±0.20	38.22±0.14^{g}	17.22±0.05^{g}	0.40±0.003^{g}	14.12±0.34^{d}	2.88 ± 0.09^{cd}
BLAE	22.07±0.08	35.54±0.28^{d}	13.47±0.20^{c}	0.31±0.003^{c}	15.17±0.40e	2.08 ± 0.03^{b}
C_6H_5OH + BLHE	18.17±0.14	34.79±0.34^{cd}	16.62±0.20^{f}	0.39±0.005^{f}	13.74±0.28^{d}	2.83 ± 0.02^{cd}
C_6H_5OH + BLEE	18.55±0.37	34.35±0.23^{c}	15.80±0.14^{e}	0.37±0.003^{e}	11.85±0.46^{c}	3.15 ± 0.14^{ef}
C_6H_5OH + BLAE	20.17±0.20	35.50±0.28^{d}	15.33±0.08^{d}	0.36±0.001^{d}	11.96±0.28^{c}	3.01 ± 0.07^{de}
BLHE + C_6H_5OH	21.11±0.12	33.42±0.17^{b}	12.31±0.04^{b}	0.29±0.001^{b}	10.85±0.23^{b}	2.67 ± 0.05^{c}
BLEE + C_6H_5OH	20.61±0.37	37.40±0.28^{f}	16.79±0.08^{fg}	0.39±0.003^{f}	8.16±0.17^{a}	4.81 ± 0.14^{g}
BLAE + C_6H_5OH	21.39±0.23	32.36±0.40^{a}	10.97±0.17^{a}	0.25±0.003^{a}	13.93±0.40^{d}	1.83 ± 0.03^{b}

Values are presented as mean ± SEM,
Values in each column which have different superscript letters are significantly different ($p < 0.05$).
C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

In animal experiments, phenol exposure via the oral route resulted in lower fetal body weights, growth retardation, and aberrant development in offspring (ATSDR, 1998). In a comparable study conducted by the National Cancer Institute (NCI) in 1980, administration of phenol to mice reduced their final body weight considerably after 13 weeks, contrary to the findings of this study. The dose of phenol and the duration of the ex-

periment may explain the discrepancy between the NCI 1980 study and the current investigation. Body weight gain and average daily gain of the mice exposed to phenol (Group II) were significantly ($p < 0.05$) higher than the control group, but these parameters were similar to the control group in the animals subjected to phenol followed by aqueous basil leaves extract. This finding revealed that basil leaves extract has a beneficial effect and can reduce phenol toxicity.

Physiological Responses

The relative weights of several organs (liver, kidney, lung, spleen, and testis) were assessed after 21 and 42 days of the experiment and are presented in Table 2 and 3, Fig 1-5. As shown in Table 2 and Figure 1, when mice were administered with phenol (Group II) for 21 days and then left untreated for another 21 days, their liver percentage significantly ($p < 0.05$) decreased by 34.55 and 39.23% respectively. The liver percentage of animals that received basil leaves aqueous extract after exposure to phenol for 21 days (Group VIII) did not significantly ($p < 0.05$) differ from the control group. Also, compared to the control group, the liver percentage decreased significantly ($p < 0.05$) in mice subjected to phenol intake for 21 days following administration with BLHE, BLEE, and BLAE (Groups IX, X, and XI) by 21.54, 25.41 and 20.99% respectively (Table 2 and Figure 1).

Additionally, there was no significant difference in the relative weights of kidneys and lungs between the control and most treated groups (Table 2 and Figure 2, 3). Moreover, the phenol administration caused an elevation in the relative weight of the kidney by 27.45% (Group II) after 42 days of the experiment. The BLEE and BLAE exposure following phenol administration prevents the increment in relative kidney and lung weights in comparison to the control group (Table 2 and Figure 2, 3).

Table 2. The relative weight of liver, kidney and lung of mice ingested phenol and various basil leaves extracts orally in different experimental groups.

Treatment Groups	Liver %		Kidney %		Lung %	
	After 21 days	After 42 days	After 21 days	After 42 days	After 21 days	After 42 days
Control	1.65 ± 0.35^{c}	1.81 ± 0.12^{d}	0.22 ± 0.03^{a}	0.37 ± 0.02^{c}	0.16 ± 0.02^{a}	0.24 ± 0.02^{abc}
C_6H_5OH	1.08 ± 0.02^{ab}	1.10 ± 0.17^{a}	0.15 ± 0.01^{ab}	0.51 ± 0.04^{e}	0.13 ± 0.01^{a}	0.29 ± 0.02^{cd}
BLHE	1.47 ± 0.08^{bc}	1.08 ± 0.04^{a}	0.17 ± 0.01^{ab}	0.22 ± 0.01^{ab}	0.17 ± 0.04^{ab}	0.37 ± 0.04^{d}
BLEE	1.71 ± 0.08^{c}	1.11 ± 0.01^{a}	0.17 ± 0.01^{ab}	0.27 ± 0.01^{bc}	0.27 ± 0.04^{b}	0.22 ± 0.02^{abc}
BLAE	1.59 ± 0.07^{c}	1.10 ± 0.05^{a}	0.13 ± 0.01^{abc}	0.25 ± 0.01^{bc}	0.13 ± 0.02^{a}	0.29 ± 0.02^{cd}
C_6H_5OH + BLHE	1.56 ± 0.17^{c}	1.10 ± 0.05^{a}	0.19 ± 0.02^{abc}	0.16 ± 0.01^{a}	0.22 ± 0.01^{ab}	0.18 ± 0.01^{ab}
C_6H_5OH + BLEE	1.46 ± 0.07^{bc}	1.24 ± 0.05^{ab}	0.18 ± 0.02^{abc}	0.24 ± 0.01^{abc}	0.12 ± 0.01^{a}	0.28 ± 0.04^{cd}
C_6H_5OH + BLAE	1.25 ± 0.07^{abc}	1.64 ± 0.08^{cd}	0.18 ± 0.02^{abc}	0.31 ± 0.03^{c}	0.21 ± 0.03^{ab}	0.29 ± 0.03^{cd}
BLHE + C_6H_5OH	1.57 ± 0.19^{c}	1.42 ± 0.06^{bc}	0.14 ± 0.01^{abc}	0.23 ± 0.01^{ab}	0.19 ± 0.02^{ab}	0.29 ± 0.03^{cd}
BLEE + C_6H_5OH	0.94 ± 0.07^{a}	1.35 ± 0.08^{b}	0.20 ± 0.01^{bc}	0.24 ± 0.02^{abc}	0.19 ± 0.02^{ab}	0.27 ± 0.02^{bc}
BLAE + C_6H_5OH	0.99 ± 0.05^{a}	1.43 ± 0.12^{bc}	0.15 ± 0.01^{c}	0.20 ± 0.01^{ab}	0.18 ± 0.04^{ab}	0.17 ± 0.02^{a}

Values are presented as mean ± SEM,
Values in each column which have different superscript letters are significantly different ($p < 0.05$).
C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

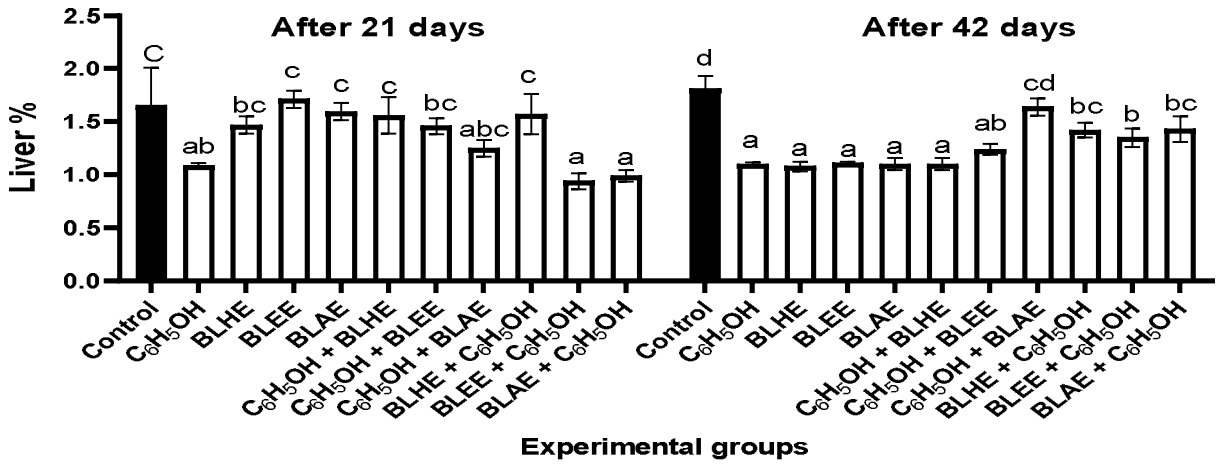

Figure 1. Relative weigh of liver of mice ingested phenol and various basil leaves extracts orally in different experimental groups

Values are presented as mean ± SEM,

Significant differences ($p < 0.05$) are indicated by different superscript letters.

C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

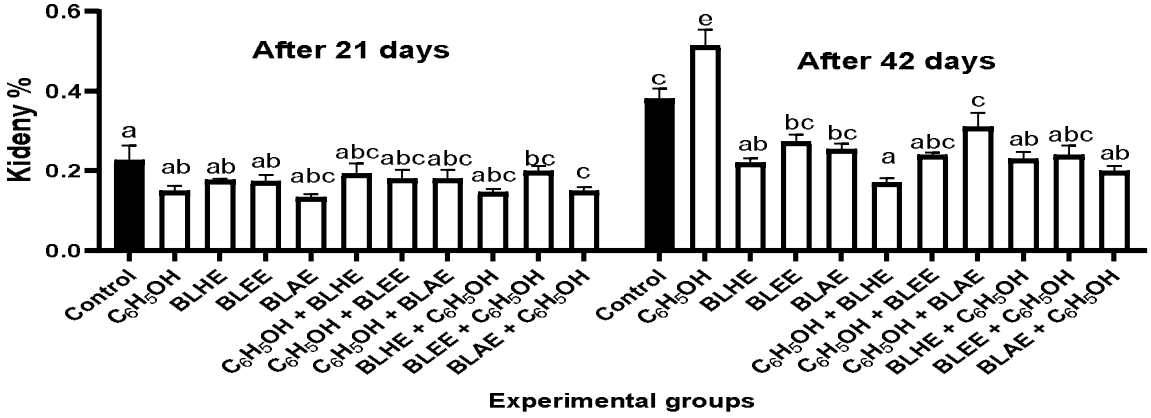

Figure 2. Relative weigh of kidney of mice ingested phenol and various basil leaves extracts orally in different experimental groups

Values are presented as mean ± SEM,

Significant differences ($p < 0.05$) are indicated by different superscript letters.

C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

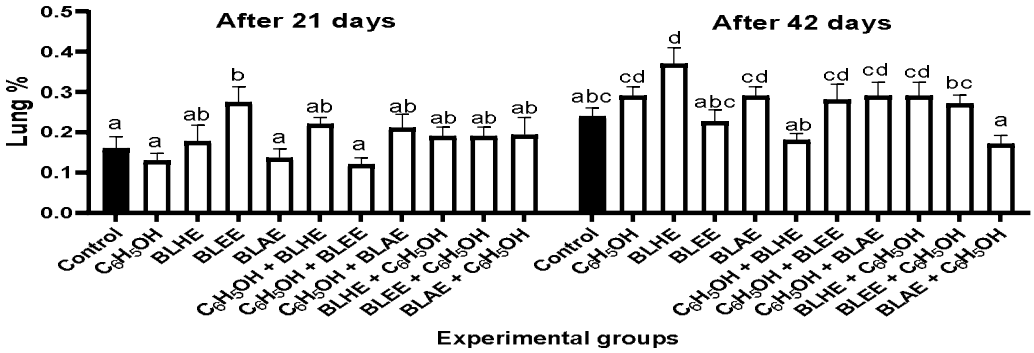

Figure 3. Relative weigh of lung of mice ingested phenol and various basil leaves extracts orally in different experimental groups

Values are presented as mean ± SEM,

Significant differences ($p < 0.05$) are indicated by different superscript letters.

C_6H_5OH = phen ol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

The percentages of spleen and testis in the mice of different groups were recorded, and the results are shown in Table 3 and Figure 4, 5. The results demonstrated that gavage phenol administration substantially altered splenic and testicular weight in mice, resulting in a significant ($p < 0.05$) increase in weights.

Table 3. The relative weight of spleen and testis of mice ingested phenol and various basil leaves extracts orally in different experimental groups.

Treatment Groups	Spleen %		Testis %	
	After 21 days	After 42 days	After 21 days	After 42 days
Control	0.20 ± 0.06^{d}	0.11 ± 0.01^{a}	0.19 ± 0.03^{ab}	0.18 ± 0.02^{bc}
C_6H_5OH	0.14 ± 0.01^{cd}	0.45 ± 0.02^{b}	0.48 ± 0.02^{cd}	0.52 ± 0.01^{e}
BLHE	0.16 ± 0.01^{cd}	0.11 ± 0.01^{a}	0.61 ± 0.02^{d}	0.75 ± 0.01^{f}
BLEE	0.10 ± 0.01^{bc}	0.86 ± 0.06^{c}	0.08 ± 0.01^{ab}	0.32 ± 0.05^{d}
BLAE	0.05 ± 0.01^{ab}	0.95 ± 0.01^{c}	0.06 ± 0.01^{a}	0.21 ± 0.01^{bc}
C_6H_5OH + BLHE	0.02 ± 0.01^{a}	0.08 ± 0.02^{a}	0.10 ± 0.01^{ab}	0.30 ± 0.01^{d}
C_6H_5OH + BLEE	0.09 ± 0.01^{abc}	0.10 ± 0.01^{a}	0.15 ± 0.02^{ab}	0.14 ± 0.01^{ab}
C_6H_5OH + BLAE	0.09 ± 0.01^{abc}	0.13 ± 0.02^{a}	0.30 ± 0.01^{bc}	0.89 ± 0.01^{g}
BLHE + C_6H_5OH	0.14 ± 0.06^{cd}	0.15 ± 0.01^{a}	0.10 ± 0.01^{ab}	0.08 ± 0.01^{a}
BLEE + C_6H_5OH	0.09 ± 0.04^{abc}	0.52 ± 0.03^{b}	0.09 ± 0.01^{ab}	0.14 ± 0.01^{ab}
BLAE + C_6H_5OH	0.05 ± 0.01^{ab}	0.11 ± 0.01^{a}	0.27 ± 0.04^{ab}	0.24 ± 0.01^{cd}

Values are presented as mean ± SEM,

Values in each column which have different superscript letters are significantly different ($p < 0.05$).

C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

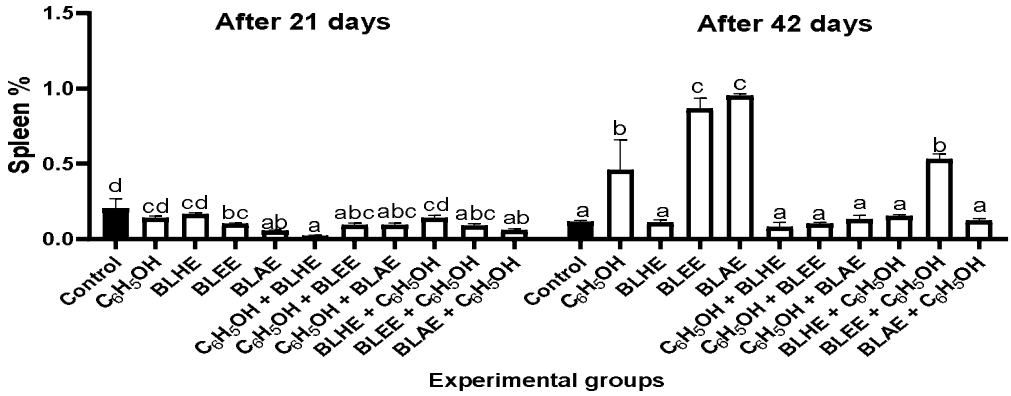

Figure 4. Relative weigh of spleen of mice ingested phenol and various basil leaves extracts orally in different experimental groups.

Values are presented as mean ± SEM,
Significant differences ($p < 0.05$) are indicated by different superscript letters.
C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

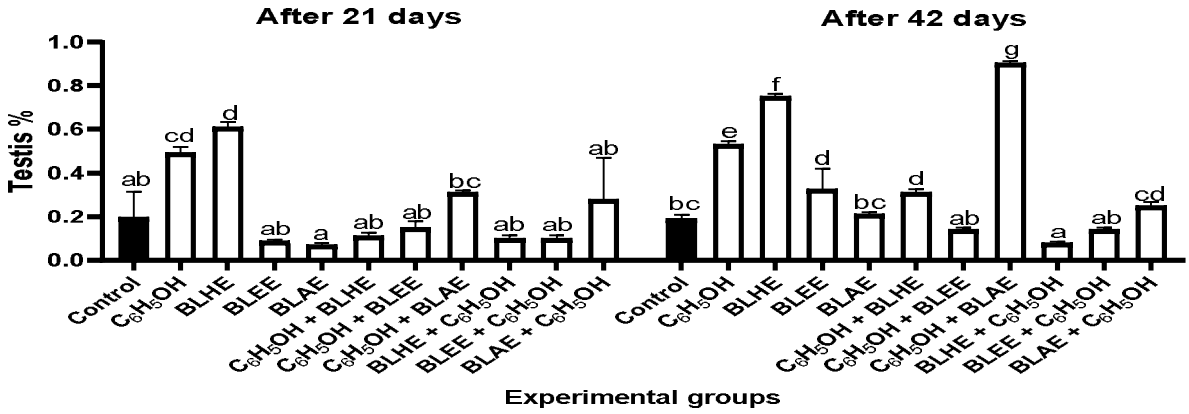

Figure 5. Relative weigh of testis of mice ingested phenol and various basil leaves extracts orally in different experimental groups

Values are presented as mean ± SEM,
Significant differences ($p < 0.05$) are indicated by different superscript letters.
C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

Gavage administration of phenol is more hazardous than drinking water (ATSDR, 2008). Chronic phenol administration causes alterations in pathological traits of animals, including the liver, lungs, and kidneys (Abd Gami *et al.,* 2014). Ingestion of phenol can cause substantial liver, lungs, and kidney damage. The liver and kidneys accumulate the most phenol-derived metabolites after oral phenol exposure (Olujimi *et al*., 2010). In line with these results, previous research conducted by Tootian *et al.,* 2012 revealed structural changes and abnormalities in the kidney in mice exposed to phenol, that indicated tissue damage. These find-

ings imply that giving mice varied amounts of phenol via gavage for 10 days could result in nephrotoxicity. In the higher phenol dose, many organs, including the spleen and testes, were found to be the principal target organs. Phenol metabolites have been detected in a number of organs in animals, including the liver, kidney, lung testes, spleen and others (CMA, 1994; Hughes and Hall, 1995). These findings support and explain why the splenic and testicular weights in the current study changed.

The basil genus is widely used in traditional medicine to cure a variety of ailments, and various studies have shown that basil leaves extracts have a wide range of pharmacological properties (Bozin *et al.,* 2006; de Almeida *et al*., 2007; Samson *et al.,* 2007). A recent study found that treating experimental animals with basil leaves extract attenuated the toxin's physiological effects. Basil leaves extract has a protective effect on a number of organs, due to its antioxidant properties (Alomar, 2020). In keeping with these findings, BLHE, BLEE and BLAE had a therapeutic and protective impact on the lungs, while BLEE and BLAE had a therapeutic effect on the liver and kidney against the toxicological effects of phenol administration. (Table 2 and Figure 1,2,3). All basil leaves extracts (BLHE, BLEE and BLAE) reduced phenol's effect on splenic weight in phenol-intoxicated mice as compared to the control group, while BLEE had a therapeutic and protective effect against phenol in the testis of chronic phenol-intoxicated mice (Table 3 and Figure 4, 5).

Hematological responses

Hematological indicators can be used to detect the adverse effects of hazardous chemicals on an animal's blood components. This may be affected by interactions between cellular constituents and harmful metabolites (Abd El-Rahman *et al.,* 2017). Hematological markers such as RBCs, Hb %, PCV %, MCV, MCH, and MCHC are regarded as a good indicators of animal physiological state and are useful in toxicity monitoring (Khan and Zafar, 2005).

As indicated in Table 4, the phenol administration promotes alterations in numerous hematological parameters in phenol intoxicated mice. RBCs, Hb% and PCV% were significantly ($P < 0.05$) increased in chronic phenol intoxicated mice (Group II) when compared with the control group by 24.93, 29.70 and 23.12% respectively. The all-basil extracts (BLHE, BLEE, and BLAE) (Group III, IV, V) revealed no significant alterations in RBCs, Hb, and PCV compared to the control group. Furthermore, in these hematological parameters BLAE caused a significant amelioration in chronic phenol-intoxicated mice (Group VIII) whereas, BLEE induced a protective effect against the toxicological effects of phenol (Group X) (Table 4), which was noticed by no significant ($P < 0.05$) difference between these groups and the control group.

Table 4. RBCs, PCV and Hb of mice ingested phenol and various basil leaves extracts orally in different experimental groups.

Treatment Groups	RBC's (10^6/µL)		PCV (%)		Hb (g/dL)	
	After 21 days	After 42 days	After 21 days	After 42 days	After 21 days	After 42 days
Control	6.72±0.20^{cd}	5.90±0.42^{ab}	40.70±0.69^{b}	31.00±2.25^{b}	13.40±0.69^{abc}	12.53±0.94^{abc}
C_6H_5OH	2.50±0.11^{a}	7.86±0.80^{de}	28.10±0.86^{a}	44.10±0.69^{d}	11.00±1.73^{ab}	16.30±0.98^{de}
BLHE	5.44±0.65^{bc}	5.90±0.55^{ab}	28.73±1.25^{a}	31.55±2.43^{bc}	11.83±1.24^{abc}	12.45±1.41^{ab}
BLEE	5.36±0.12^{b}	6.54±0.15^{bc}	27.65±0.43^{a}	34.90±1.44^{bc}	9.95± 0.37^{a}	14.10±1.27^{bcd}
BLAE	6.24±0.22^{bcd}	6.33±0.34^{abc}	28.56±1.41^{a}	33.66±2.19^{bc}	13.40±0.55^{abc}	12.66±0.92^{abc}
C_6H_5OH + BLHE	5.51±0.58^{bc}	8.13±0.43^{e}	28.90±0.51^{a}	44.60±2.59^{d}	11.70±1.44^{abc}	17.95±0.25^{e}
C_6H_5OH + BLEE	5.24±0.51^{b}	7.45±0.14^{cde}	27.70±0.46^{a}	37.70±2.54^{c}	11.00±1.73^{ab}	15.70±1.44^{cde}
C_6H_5OH + BLAE	6.95±0.28^{d}	5.59±0.51^{ab}	37.00±0.69^{b}	30.20±0.63^{b}	14.40±0.69^{bc}	12.00±1.15^{ab}
BLHE + C_6H_5OH	6.75±0.75^{cd}	5.13±0.18^{a}	38.70±0.28^{b}	24.00±0.40^{a}	14.20±1.27^{bc}	10.80±0.57^{a}
BLEE + C_6H_5OH	6.80±0.23^{cd}	6.83±0.15^{bcd}	36.80±0.90^{b}	35.60±1.21^{bc}	13.90±0.86^{bc}	14.20±0.63^{bcd}
BLAE + C_6H_5OH	7.58±0.24^{d}	8.21±0.19^{e}	40.70±1.57^{b}	47.95±0.54^{d}	15.35±0.66^{c}	16.40±0.34^{de}

Values are presented as mean ± SEM,
Values in each column which have different superscript letters are significantly different ($p < 0.05$).
RBC's = red blood cells; PCV = peaked cell volume; Hb = hemoglobin, C_6H_5OH = phenol, BLHE = basil leaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

In addition, after 21 days of the experimental period, MCV was significantly ($P < 0.05$) decreased in all treated groups (Table 5). Whereases, MCHC was significantly ($P < 0.05$) increased in the most of the treated groups after the same time of the experimental period. Except in BLHE + C_6H_5OH and BLAE + C_6H_5OH treated groups (Group IX and XI) no significant ($P < 0.05$) differences were observed in MCV, MCH and MCHC values in all treated groups at the end of the experimental period (Table 5).

The coefficient of variation of red cell volume distribution width (RDW-CV) and standard deviation of red cell volume distribution width (RDW-SD) levels are used to represent RDW values. The RDW-SD is a measurement in femtoliters of the width of the red cell distribution curve (fL). The RDW-CV is a calculation that calculates both the width of the distribution curve and the size of the mean cell. To describe a population of RBCs, the RDW is combined with the indices (MCV, MCH, and MCHC).

Table 5. MCV, MCH and MCHC of mice ingested phenol and various basil leaves extracts orally in different experimental groups.

Treatment Groups	MCV (fL)		MCH (pg)		MCHC (g/dL)	
	After 21 days	After 42 days	After 21 days	After 42 days	After 21 days	After 42 days
Control	65.00±1.15^{c}	52.63±0.72^{bcd}	21.30±0.86^{a}	21.16±0.08^{a}	32.90±0.80^{a}	40.36±0.46^{bc}
C_6H_5OH	51.30±2.59^{ab}	56.20±1.90^{de}	20.00±1.73^{a}	20.70±1.09^{a}	39.10±1.73^{b}	36.90±1.27^{ab}
BLHE	52.96±0.67^{ab}	53.40±0.80^{bcd}	21.76±0.57^{a}	20.95±0.43^{a}	41.20±0.56^{b}	39.35±0.20^{bc}
BLEE	51.55±0.54^{ab}	53.50±1.27^{bcd}	18.45±0.60^{a}	21.50±0.86^{a}	35.90±0.80^{ab}	40.40±1.90^{bc}
BLAE	53.53±1.12^{ab}	53.16±1.37^{bcd}	21.43±1.07^{a}	19.90±0.70^{a}	40.26±2.61^{b}	37.53±0.31^{abc}
C_6H_5OH + BLHE	52.50±2.88^{ab}	54.90±0.28^{cd}	21.20±1.84^{a}	22.20±0.86^{a}	40.40±3.00^{b}	40.50±1.78^{bc}
C_6H_5OH + BLEE	52.90±0.69^{ab}	50.70±1.84^{b}	20.90±0.46^{a}	21.00±1.15^{a}	39.70±1.27^{b}	41.60±1.84^{cd}
C_6H_5OH + BLAE	53.30±1.90^{ab}	50.80±1.32^{b}	20.70±1.27^{a}	20.10±0.75^{a}	38.90±0.86^{b}	39.70±1.38^{bc}
BLHE + C_6H_5OH	51.90±2.54^{ab}	46.90±0.05^{a}	21.00±1.15^{a}	20.95±0.77^{a}	40.50±0.69^{b}	44.85±1.64^{d}
BLEE + C_6H_5OH	55.70±1.90^{b}	52.15±0.66^{bc}	20.30±0.57^{a}	20.70±0.46^{a}	37.20±2.34^{ab}	39.80±0.40^{bc}
BLAE + C_6H_5OH	49.70±0.80^{a}	58.40±0.09^{e}	20.15±0.20^{a}	19.90±0.17^{a}	40.70±0.23^{b}	34.15±0.31^{a}

Values are presented as mean ± SEM,
Values in each column which have different superscript letters are significantly different ($p < 0.05$).
MCV = mean corpuscular volume; MCH = mean corpuscular hemoglobin; MCHC= mean corpuscular hemoglobin concentration, C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

As a result, RDW-SD and RDW-CV were determined in this study, and the results are shown in Table 6. According to the results, RDW-SD was significantly ($P < 0.05$) decreased in all treated groups after 21 days of the experimental period. At the end of the experimental period no significant ($P < 0.05$) differences were observed in RDW-SD and RDW-cv levels in the most of the treated groups.

Table 6. RDW-SD and RDW-cv of mice ingested phenol and various basil leaves extracts orally in different experimental groups.

Treatment Groups	RDW-SD (fL)		RDW-CV (%)	
	After 21 days	**After 42 days**	**After 21 days**	**After 42 days**
Control	74.40±1.03^{c}	31.60±2.13^{bcd}	29.60±0.92^{b}	15.46±0.97^{ab}
C_6H_5OH	35.30±1.27^{ab}	31.60±2.42^{bcd}	17.80±0.75^{ab}	14.50±1.38^{a}
BLHE	36.56±2.70^{b}	36.20±1.61^{d}	17.76±1.12^{ab}	17.60±1.03^{bc}
BLEE	35.30±1.09^{ab}	31.60±1.21^{bcd}	17.70±0.34^{ab}	15.20±0.75^{ab}
BLAE	32.20±0.60^{ab}	30.33±1.61^{abc}	27.53±12.09^{ab}	14.73±0.88^{ab}
C_6H_5OH + BLHE	33.40±1.27^{ab}	32.50±0.51^{bcd}	16.40±0.63^{ab}	15.30±0.17^{ab}
C_6H_5OH + BLEE	37.20±0.86^{b}	26.00±2.30^{a}	18.10±0.57^{ab}	13.20±1.27^{a}
C_6H_5OH + BLAE	29.70±2.54^{a}	27.90±1.27^{ab}	14.40±0.51^{a}	14.20±1.21^{a}
BLHE + C_6H_5OH	29.70±0.51^{a}	35.30±1.09^{cd}	14.80±1.27^{a}	19.40±0.63^{c}
BLEE + C_6H_5OH	34.48±4.16^{ab}	27.90±0.00^{ab}	22.59±5.56^{ab}	13.80±0.17$_{a}$
BLAE + C_6H_5OH	29.75±1.06^{a}	35.30±1.09^{cd}	15.40±0.28^{a}	15.60±0.46^{ab}

Values are presented as mean ± SEM,
Values in each column which have different superscript letters are significantly different ($p < 0.05$).
RDW-SD = standard deviation of red blood cell distribution width, RDW-CV = coefficient of variation of red blood cell distribution width; C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

Platelets (also known as thrombocytes) are the second most common blood cells produced in the bone marrow. They circulate in the bloodstream and assist in hemostasis and wound healing (Pogorzelska *et al*., 2020). The mean platelet volume (MPV), platelet distribution width (PDW), plateletcrit (PCT) and the platelet-large cell ratio (P-LCR) are the most commonly evaluated platelet indicators (Budak *et al.,* 2016). The most commonly investigated platelet parameter is mean platelet volume (MPV), which refers to the size of platelets in the blood (Demirin *et al*., 2011). Platelet distribution width (PDW) is a platelet anisocytosis indicator that defines the size distribution of platelets produced by megakaryocytes and rises when platelets are activated (Osselaer *et al.,* 1997). Plateletcrit (PCT) is a measurement of total platelet mass as a percentage of blood volume occupied (Budak *et al*., 2016). The platelet larger cell ratio (P-LCR) is a percentage of all platelets in the bloodstream with a volume greater than 12 fL which is one of the indicators of platelet activity (Hong *et al*., 2014).

Platelet counts and their indices were assessed and the results are presented in Table 7 and 8. According to the obtained data, there were no significant ($P < 0.05$) differences in PLT, MPV, PDW, PCT and P-LCR values between all of the most administered groups. PDW was significantly ($P < 0.05$) increased in all treated groups after 21 days of the experimental period except in BLEE and BLAE + C_6H_5OH treated groups (Group IV and XI) (Table 7). P-LCR was significantly decreased by 43,25 and 38,73 % in C_6H_5OH + BLAE and BLEE + C_6H_5OH treated groups (Group VIII and X) compared to the control group.

Table 7. PLT, MPV and PDW of mice ingested phenol and various basil leaves extracts orally in different experimental groups.

Treatment Groups	PLT (10^3/µL)		MPV (fL)		PDW %	
	After 21 days	After 42 days	After 21 days	After 42 days	After 21 days	After 42 days
Control	291.00±2.88^{ab}	255.33±7.94^{ab}	7.20±0.17^{ab}	7.63±0.28^{a}	7.10±0.11^{a}	9.10±0.47^{bc}
C_6H_5OH	192.00±3.46^{ab}	177.00±3.46^{ab}	7.40±0.11^{b}	7.60±0.86^{a}	8.70±0.23^{bc}	10.00±1.15^{bc}
BLHE	425.33±7.53^{c}	318.50±9.77^{b}	8.06±0.27^{c}	7.45±0.02^{a}	9.10±0.20^{cd}	9.45±0.60^{bc}
BLEE	231.00±9.62^{ab}	261.00±2.30^{ab}	7.05±0.08^{ab}	7.20±0.23^{a}	7.25±0.37^{ab}	9.20±0.34^{bc}
BLAE	281.00±6.92^{ab}	229.33±4.24^{ab}	7.33±0.33^{ab}	7.43±0.23^{a}	10.16±1.09^{cd}	9.26±0.47^{bc}
C_6H_5OH + BLHE	430.00±3.46^{c}	262.00±5.98^{ab}	7.30±0.05^{ab}	7.45±0.20^{a}	10.20±0.63^{cd}	10.00±1.03^{bc}
C_6H_5OH + BLEE	166.00±2.30^{a}	161.00±3.46^{a}	7.30±0.11^{ab}	7.10±0.28^{a}	9.20±0.34^{cd}	8.90±0.69^{b}
C_6H_5OH + BLAE	288.00±3.46^{ab}	278.00±2.88^{ab}	7.20±0.17^{ab}	7.00±0.15^{a}	9.70±0.51^{cd}	11.50±1.27^{c}
BLHE + C_6H_5OH	327.00±2.30^{bc}	219.50±8.18^{ab}	6.90±0.46^{ab}	7.20±0.05^{a}	10.50±0.69^{d}	6.00±0.05^{a}
BLEE + C_6H_5OH	229.78±5.22^{ab}	248.00±9.25^{ab}	7.42±0.06^{b}	7.05±0.08^{a}	9.00±0.09^{cd}	10.75±0.31^{bc}
BLAE + C_6H_5OH	197.50±8.76^{ab}	242.16±4.66^{ab}	6.65±0.02^{a}	8.10±0.05^{a}	6.90±0.28^{a}	9.75±0.89^{bc}

Values are presented as mean ± SEM,

Values in each column which have different superscript letters are significantly different ($p < 0.05$).

PLT= platelets; MPV = mean platelet volume, PDW =platelet distribution width; C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

Table 8. PCT and P-LCR of mice ingested phenol and various basil leaves extracts orally in different experimental groups.

Treatment Groups	PCT (%)		P-LCR (%)	
	After 21 days	After 42 days	After 21 days	After 42 days
Control	0.20±0.05^{ab}	0.19±0.04^{a}	11.80±0.11^{bc}	12.16±2.26^{cd}
C_6H_5OH	0.14±0.01^{ab}	0.13±0.02^{a}	9.70±0.34^{abc}	11.90±1.44^{bcd}
BLHE	0.37±0.13^{c}	0.23±0.06^{a}	15.06±2.31^{c}	10.15±1.18^{abcd}
BLEE	0.16±0.01^{ab}	0.18±0.02^{a}	4.96±0.95^{a}	8.60±0.17^{abc}
BLAE	0.20±0.03^{ab}	0.16±0.04^{a}	10.90±4.45^{bc}	10.96±1.34^{abcd}
C_6H_5OH + BLHE	0.31±0.01^{bc}	0.19±0.02^{a}	9.90±0.69^{abc}	13.53±1.67^{d}
C_6H_5OH + BLEE	0.12±0.02^{a}	0.11±0.02^{a}	11.50±1.15^{bc}	7.80±0.51^{abc}
C_6H_5OH + BLAE	0.16±0.04^{ab}	0.19±0.02^{a}	11.20±0.86^{bc}	6.90±0.28^{a}
BLHE + C_6H_5OH	0.22±0.02^{abc}	0.15±0.01^{a}	7.40±0.34^{ab}	8.00±1.15^{abc}
BLEE + C_6H_5OH	0.17±0.02^{ab}	0.17±0.02^{a}	10.55±1.23^{bc}	7.45±1.47^{ab}
BLAE + C_6H_5OH	0.13±0.01^{a}	0.13±0.05^{a}	10.00±0.657^{abc}	14.45±1.81^{d}

Values are presented as mean ± SEM,
Values in each column which have different superscript letters are significantly different ($p < 0.05$).
PCT = procalcitonin; P-LCR = platelet large cell ratio; C_6H_5OH = phenol, BLHE = basil leaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

White blood cells (leukocytes) play a vital role in immune function by protecting the body from antigen invasion. The type of granule in their cytoplasm and the form of their nucleus are used to classify them. As a result, white blood cells are divided into two groups: granulocytes and agranulocytes. Granulocytes include neutrophils, eosinophils, and basophils, while agranulocytes include lymphocytes and monocytes, which can go through numerous cycles of activity before dying (Junqueira *et al.,* 1992). The lymphocytes assist in the recognition of a wide range of antigens, differentiation and maturation to functional capacity, antigen response, and immunologic memory (Klein and Horejí, 1997). Phagocytic activity is present in neutrophils and monocytes. Foreign particles, cell waste materials, and bacteria are all attacked and destroyed by them (Dacie and Lewis, 1991).

As a consequence, the number of white blood cells, lymphocyte %, and neutrophil % were measured, and the findings are shown in Table 9. Phenol exposure caused a 58, 18% increase in white blood cell count (Group II) in mice as compared to the control group. At the end of the experiment, the white blood cell count in the C_6H_5OH + BLAE and BLAE + C_6H_5OH treated groups (Group VIII and XI) was significantly ($P < 0.05$) higher than in the control group. Also, lymphocytes % and neutrophils % were significantly ($P < 0.05$) decreased by 5,75% and 71,42% in BLAE + C_6H_5OH (Group XI) and C_6H_5OH + BLAE (Group VIII) treated group compared to the control group respectively (Table 9).

Table 9. White blood cells, lymphocytes and neutrophils of mice ingested phenol and various basil leaves extracts orally in different experimental groups.

Treatment Groups	White blood cells (WBCs) (10^3/mm^3)		Lymphocytes (%)		Neutrophils (%)	
	After 21 days	After 42 days	After 21 days	After 42 days	After 21 days	After 42 days
Control	2.90±0.17^{ab}	2.30±0.43^{ab}	92.80±1.44^{a}	94.06±1.15^{bc}	3.60±0.23^{bc}	4.20±0.81^{b}
C_6H_5OH	2.50±0.11^{ab}	5.50±0.46^{d}	94.30±1.90^{a}	97.60±1.27^{c}	3.20±0.86^{abc}	1.30±0.23^{ab}
BLHE	2.95±0.99^{ab}	1.90±0.01^{a}	94.83±1.17^{a}	92.10±0.34^{ab}	3.46±0.12^{abc}	4.40±0.17^{b}
BLEE	3.15±0.14^{ab}	1.80±0.11^{a}	96.25±1.14^{a}	95.10±1.84^{bc}	2.60±0.11^{abc}	3.60±0.46^{ab}
BLAE	2.90±1.00^{ab}	3.36±0.60^{bc}	95.70±1.05^{a}	95.80±1.15^{bc}	1.80±0.95^{a}	2.40±0.70^{ab}
C_6H_5OH + BLHE	2.00±0.51^{a}	2.65±0.43^{ab}	96.80±0.86^{a}	95.20±0.46^{bc}	2.20±0.15^{abc}	1.80±0.93^{ab}
C_6H_5OH + BLEE	0.80±0.11^{a}	2.30±0.23^{ab}	94.70±0.69^{a}	95.20±0.46^{bc}	3.90±0.46^{c}	1.60±0.11^{ab}
C_6H_5OH + BLAE	3.30±0.28^{ab}	3.80±0.46^{c}	96.10±1.21^{a}	93.10±1.38a^{bc}	2.30±0.23^{abc}	1.20±0.05^{a}
BLHE + C_6H_5OH	2.70±0.51^{ab}	2.25±0.20^{ab}	95.40±2.02^{a}	93.55±1.18^{bc}	2.90±0.23^{abc}	4.35±0.89^{b}
BLEE + C_6H_5OH	12.50±1.81^{b}	2.45±0.14^{ab}	74.79±1.35^{a}	93.60±0.69^{bc}	1.86±0.92^{ab}	3.40±0.17^{ab}
BLAE + C_6H_5OH	2.25±0.31^{a}	5.20±0.17^{d}	94.55±1.14^{a}	88.65±1.37^{a}	2.70±0.17^{abc}	4.35±0.94^{b}

Values are presented as mean ± SEM,
Values in each column which have different superscript letters are significantly different ($p < 0.05$).
C_6H_5OH = phenol, BLHE = basil l eaves hexane extract, BLEE = basil leaves ethanolic extract, BLAE = basil leaves aqueous extract

Two of the adverse health effects of phenol toxicity in humans and animals are hematotoxicity and immunotoxicity (Zeman *et al.* 1990; Louei Monfared and Salati 2012). The phenol cytotoxicity attribute to the potential of phenoxyl-type radicals to damage epithelial cell membrane integrity (Tootian *et al.* 2012). Chronic phenol exposure may have an impact on the functions of immune and hematopoietic systems (Baj *et al.* 1994). A complete blood count (CBC) is a useful technique for identifying an animal's clinical state because it offers quantitative and qualitative information on all blood cells (Rizzi *et al.* 2010). As a result, the impacts of phenol administration on hematological parameters were detected in the current study, with an increase in various hematological parameters such as RBCs, Hb% and PCV% (Table 4). In contrast, a study conducted by EFSA (2013) found a significant dose-related decrease in erythrocyte counts when compared to control levels. At the highest phenol dose, their investigation found a slight reduction in hematocrit levels, but no significant changes in leucocyte counts or leucocyte differentials. The disagreement between the EFSA (2013) and the current investigation could be attributed to differences in phenol dose, treatment method, and experiment period.

In addition, in the present study basil leaves extracts had a beneficial effect in mice against the hematotoxin effects of phenol. This is in line with the findings from previous study which found that *Ocimum basilicum* recovered various hematological and immunological parameters in male albino adult mice after $AlCl_3$ intoxication (Ali *et al.,* 2017).

The ingestion of basil leaves extract had no effect on the white blood cells count, lymphocytes %, and neu-

trophils % in the current investigation. BLHE, BLEE, and BLAE were revealed to protect mice from the adverse immunological effects of phenol. This is consistent with the findings of Ofem *et al*.(2012), who found that total WBC counts were not significantly affected following basil leaves extract administration. However, in their study analysis of the differential counts revealed that high doses of the basil extract resulted in a decrease in lymphocyte count but an increase in neutrophil count in the rats, leaving the overall white blood cells count relatively unchanged. Cell margination, rather than destruction, could be the cause of the drop in lymphocyte count. It's also likely that the extract contains substances that stimulate the production of neutrophils in the bone marrow and their release into the bloodstream. It has been reported that *Ocimum basilicum* modulates the cell-mediated as well as humoral immune response that could be due to the presence of flavonoids and terpenoids (Mediratta *et al*., 2002).

Conclusion

The effect of phenol on growth performance indicators, relative weight of various organs, hematological and immunological parameters in mice was reduced by all basil leaves extracts (BLHE, BLEE, and BLAE) in the current study. The presence of numerous phytochemicals in basil extracts such as polyphenols, flavonoids, terpenoids, and others could explain the antitoxic properties of various basil extracts which noticed in this study. Finally, the findings show that basil leaves extracts can be employed as an antitoxic agent and have a variety of health benefits. To fully understand the mechanism of action of basil leaves extracts as an anti-toxin agents, more research is required.

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Assiut J. Agric. Sci., 52 (4) 2021 (66-84) *ISSN: 1110-0486*
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النشاط المحتمل لمستخلصات أوراق الريحان الحلو (*Ocimum basilicum* L.) على التغيرات الفسيولوجية والسمية الدموية المستحثة بالفينول في الفئران

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الملخص

صممت هذه الدراسة لتقييم تأثير مستخلصات أوراق الريحان الحلو على مؤشرات أداء النمو، والاستجابات الفسيولوجية والدموية في الفئران المعاملة بالفينول. تم تقسيم ٦٦ فأرًا من ذكور الفئران البيضاء بالتساوي إلى ١١ مجموعة. استخدمت المجموعة الأولي كمجموعة ضابطة. أما المجموعة الثانية تعرضت يوميا عن طريق الفم لـ ١٨٠ مجم فينول/ كجم من وزن الجسم لمدة ٢١ يوماً. أما المجموعات الثالثة والرابعة والخامسة فقد عوملت عن طريق الفم بمستخلص هكساني، ايثانولي، مائي لأوراق الريحان بمقدار ٤٠٠ مجم/ كجم من وزن الجسم على التوالي لمدة ٢١ يوماً. بينما تم معاملة المجموعات السادسة والسابعة والثامنة عن طريق الفم بمستخلص هكساني، ايثانولي، مائي لأوراق الريحان بمقدار ٤٠٠ مجم / كجم من وزن الجسم على التوالي لمدة ٢١ يوماً عقب المعاملة عن طريق الفم بـ ١٨٠ مجم فينول/ كجم من وزن الجسم لمدة ٢١ يوماً أخري. أما المجموعات التاسعة والعاشرة والحادية عشر فقد عوملت عن طريق الفم بمستخلص هكساني، ايثانولي، مائي لأوراق الريحان بمقدار ٤٠٠ مجم/ كجم من وزن الجسم على التوالي لمدة ٢١ يوماً قبل معاملتها عن طريق الفم بـ ١٨٠ مجم فينول/ كجم من وزن الجسم لمدة ٢١ يوماً أخري. أدت معاملة الفئران بالفينول الي أنخفاض الوزن النسبي للكبد بينما زاد الوزن النسبي للكلى والطحال والخصيتين. كرات الدم الحمراء، ونسبة الهيموجلوبين، وطول عمود الدم فقد زادت زيادة كبيرة. أدت المعاملة بمستخلصات أوراق الريحان إلى تحسين بعض مؤشرات أداء النمو، وتقليل التأثيرات الضارة للفينول على بعض الأعضاء وقياسات الدم. وتؤكد نتائج هذه الدراسة أنه يمكن استخدام مستخلصات أوراق الريحان كعامل مضاد للسموم بالإضافة الي انه له مدي واسع من الفوائد الصحية.