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Effect of Bread Improver Dough Conditioner used in Commercial Bread Production on Some Biochemical, Oxidative Stress and Haematological Parameters in Male Wistar Rats

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ABSRTACT

Bread improver dough conditioner (BIDC) is a blend of ingredients designed to enhance bread texture, volume, and taste. This study aimed to investigate the effect of BIDC used in bread production on human health, focusing on its potential impact on hematological, oxidative stress and biochemical markers in male *Wistar* rats. This study, which lasted 28 days, involved 20 male *Wistar* rats distributed in 4 groups, each group containing 5 animals. The first group was administered the normal diet, groups 2, 3 and 4 were administered three different doses consecutively 250 mg/kg, 1000 mg/kg and 2000 mg/kg of BIDC, and fed with a normal diet. In this study, results obtained revealed a significant decrease ($p > 0.05$) in body weight but no significant changes ($p > 0.05$) in liver and kidney weights of rats administered BIDC compared to the control. The rats administered 2000 mg/kg BIDC had a significant increase ($p < 0.05$) in serum superoxide dismutase levels and a decrease in catalase levels in comparison to the control. Biochemically, BIDC at 2000 mg/kg revealed no significant changes ($p > 0.05$) in alanine aminotransferase, cholesterol, high-density lipoprotein cholesterol levels, creatinine and urea levels, but decreased ($p<0.05$) triglycerides and aspartate aminotransferase levels, while increasing low-density lipoprotein cholesterol levels compared to the control. A significant increase ($p>0.05$) in platelet counts was recorded for 2000 mg/kg BIDC, but no significant changes ($p>0.05$) for white blood cells, red blood cells, hemoglobin and hematocrit levels. Liver and kidney histopathology revealed no significant morphological damage across groups. In conclusion, BIDC exhibited no significant dose-dependent toxicity, except for final body weight and LDL-C levels suggesting that these substances are safe for consumption in low doses.

Keywords: Food additives, Bread improver dough conditioner, Toxicity, Bread, Antioxidant enzymes

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Introduction

Globally, the food industry relies significantly on food additives to meet consumer demand for safe, appealing, and convenient products. Food additives are substances or mixtures added to food at various stages, including the preparation, the processing, the manufacturing, treatment processes and packaging. These additives modify the chemical, biological, sensory or physical properties of food, enhancing its taste, flavour, appearance or other desirable characteristics, while contributing little or nothing to its nutritional value. [1] These substances are rigorously evaluated by agencies such as the European Food Safety Authority (EFSA) and Food and Drug Administration (FDA) for safety, whereas public skepticism and demand for "clean label" foods have grown, further driving innovation and reformulation strategies in food manufacturing.

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Food Additives may be classified as preservatives, antioxidants, emulsifiers, colorants, etc. Preservatives inhibit microbial growth to extend shelf life and reduce foodborne illnesses. Examples include nitrates used in cured meats, potassium sorbate, and sodium benzoate.[2] Antioxidants prevent oxidative rancidity in fats and oils, and they include ascorbic acid, tocopherols, and butylated hydroxytoluene (BHT).[1 3] Emulsifiers, stabilizers, and thickeners are compounds that enhance texture and consistency, and they are Lecithin, carrageenan, and guar gum. [4] Colorants a category of food additives known as color additives which restore or enhance the visual appeal of food being synthetic (e.g., tartrazine) or natural (e.g., beetroot red, turmeric). [5] Not forgetting safety in consumption of these additives, all food additives must undergo a rigorous risk assessment process before approval (Regulatory Frameworks and Safety Evaluation, scientific advice on additive safety) establishing acceptable daily intake (ADI) levels is provided for by the Joint FAO/WHO Expert Committee on Food Additives (JECFA).[6] National bodies like the FDA maintain lists such as the "Generally Recognized As Safe" (GRAS) substances, while EFSA assigns E-numbers to approved additives. Consumers are increasingly wary of synthetic additives, prompting food manufacturers to use natural alternatives or reformulate products to reduce additive load, resulting in the Clean Label Movement. [7]

More so, food, which is a necessity for individuals to exist or other living organisms, is required for optimum health, to fulfill one's duties in a commendable manner, achieve adequate growth, and recover from illnesses, attain adequate child development and to survive.[8] Food items are of different types.[9] Bread (which is food) in its various forms is considered staple food for many people around the world.[10]

Bread improvers and dough conditioners are additives used widely in commercial baking for the purpose of enhancing quality, consistency,

and processing performance of bread. These improvers are typically complex blends of functional ingredients that act complementarily to modify dough rheology, strengthen gluten networks, improve fermentation tolerance, and extend shelf life. As the baking industry has scaled toward mechanized and high-speed production systems, the use of bread improvers has become almost a prerequisite for ensuring uniform product quality under variable processing conditions.[11 12]

The composition of bread improvers may vary based on intended use and desired product characteristics, but most formulations include a combination of: enzymes (e.g., amylases, xylanases, proteases, lipases) to improve dough extensibility and increase gas retention capacity,[13 14] Oxidizing agents like ascorbic acid or potassium bromate to enhance gluten strength, [10] Emulsifiers like lecithin, sodium stearoyl lactylate and diacetyl tartaric acid ester of mono- and diglycerides improve crumb softness and loaf volume,[15] while reducing agents such as cysteine or glutathione modify dough viscosity and machinability. Regardless of the technological benefits these additives exhibit, there are concerns about the potential adverse effects of some dough conditioner components. For instance, potassium bromate, previously a common oxidizer, due to its potential carcinogenic properties, has been restricted or banned in numerous countries.[16] Additionally, long-term consumption of emulsifiers and synthetic additives has been associated with gastrointestinal issues and alterations in gut microbiota, although findings remain inconclusive and depend on dosage and individual susceptibility.[17] These concerns, coupled with rising consumer awareness and demand for transparency, have led to the "clean label" movement—favoring natural or minimally processed alternatives.

Bread improvers and dough conditioners are more important than ever. Additives, in essence, are used to ensure processed foods remain stable and safe throughout the supply chain, from manufacturing and industrial kitchens to warehouses, shops and then consumers.[18] Studies show that certain food additives may cause adverse effects on hematological parameters, such as changes in blood cell counts and oxidative stress markers. The World Health Organization (WHO) estimates that approximately 70 to 80% of processed foods contain food additives and 80 to 90 % of baked foods contain additives.[19] Furthermore, 30 to 40% of chronic diseases are attributed to the consumption of processed foods.[20]

With a rise in consumer focus on food safety, nutrition, and ingredient transparency, this study sought to determine if bread (a staple), which is produced with food additives (BIDC), poses undesirable effects on biochemical, oxidative stress, and hematological parameters, which might have resultant adverse effects on the health of populations.

Materials and Methods

Experimental design

In this study, twenty male *Wistar* rats (weighing approximately 100 - 120g) were used and housed in plastic cages at the animal house in Bingham University, Nasarawa State, Nigeria and fed rat chow and water *ad libitum*. These animals were categorized into 4 equal groups of 5 rats each; the first is the control group, the second, third and fourth groups served as the treatment groups, and rats in these groups were administered the BIDC and fed with a normal diet and water. Treatment was administered using three different doses of the food additive (250 mg/kg/kg, 1000 mg/kg and 2000 mg/kg) daily for twenty-eight days.

Food Additive Composition

The food additive Bread Improver Dough Conditioner (BIDC) contained enzymes (0.5g), lecithin (30g), ascorbic acid (4g), corn starch (965g), and azodicarbonamide (0.5g) in solid form. The BIDC manufactured was purchased from Mararaba market, Nasarawa State and used for this study.

Weight Determination and Sample Preparation

Throughout the experimental period, Body weights were recorded once a week using a digital weighing scale, Model WJN-184 (5kg x 0.1g), CGOLDENWALL, China. After 28 days of treatment, the rats were fasted overnight, the blood was collected through cardiac puncture. The rat liver, kidney and heart were dissected and weighed. Blood samples were kept in plain sterile bottles (for serum) and EDTA tubes (for hematological analysis).

Hematology analysis

Full blood count was performed on blood collected in EDTA tubes using a hematology auto-analyzer (XN-350, Sysmex XN-Series technology), estimated according to the manufacturer's instructions for parameters such as red and white blood cells, hemoglobin, hematocrit and others.

Biochemical Assessment

Serum was used for biochemical evaluations as follows: lipid profile, kidney function, liver enzyme activities. Creatinine levels were determined using the Bartels and Bohmer colorimetric method, and urea was measured using the urease-Berthelot method,[21 22] involving hydrolysis of urea to ammonia by urease, followed by photometric measurement of ammonia via Berthelot's reaction. SOD was determined according to the manufacturer's manual (Elabscience Total Superoxide Dismutase Activity Assay Kit manual). The principle states SOD inhibits O_2, mediated by hydroxylamine oxidation, reducing purple chromogen formation (550 nm). Therefore, activity is defined as the amount of SOD causing 50% inhibition of O_2. Catalase was determined (according to the manufacturer's manual, Elabscience Catalase (CAT) Activity Assay Kit). The principle followed the reaction that catalase (CAT), which can decompose into H_2O_2, can be rapidly halted by ammonium molybdate to generate a yellowish complex measured at 405 nm. Reitman and Frankel.[23] described a method that was used to determine alanine aminotransferase (ALT) and aspartate aminotransferase (AST). Total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C), levels were measured using Chemistry Autoanalyzer by manufacturers' kits (SpetrumLab kits, Spectra Group Diagnostics, Egypt).

Histopathological Assessment

For histological examination, liver and kidney tissues were fixed in 10% neutral buffered formalin.[24] Dehydrated tissue samples were cleaned in xylene and fixed in paraffin wax at 60°C and 5 µm thick sections were obtained using a microtome, mounted on 3-aminopropyltriethoxysilane-coated slides, and dried at 37°C for 24 hours.[25] The sections were deparaffinized with xylene, rehydrated in alcohol, and stained with hematoxylin and eosin. After drying, the slides were mounted on a light microscope for histological examination.[26]

Statistical Analysis

Data were analyzed by One-way analysis of variance (ANOVA) using SPSS v22 software (IBM, USA), and Duncan's multiple range test (DMRT) was the post-hoc test employed. Experimental results were presented as mean ± standard error of the mean (SEM) for a p-value $\leq$ 0.05 level of significance.

Results and Discussion

All groups showed similar initial body weights with no significant differences (Table 1), however, after 28 days, the normal control had the highest final body weight (212.00 g), followed by the 250mg/kg (203.33 g) and 1000mg/kg BIDC groups (203.00 g). The 2000 mg/kg BIDC group showed the lowest final weight (198.67 g), which differed significantly from the normal group, suggesting dose-dependent weight suppression. BIDC shows a dose-dependent effect where BIDC doses appear to reduce body weight compared to the normal group, which is a sign of toxicity.[27] Notably, BIDC's weight-modulating properties mirror mechanisms observed with several dietary bioactivities and food additives, underscoring the physiological plausibility of our results. According to [28 29] nitrite treatments resulted in a reduction in body weight gain. Also, findings from a study, recorded a reduction in body weight resulting from colorant supplementation. [30 31]

The results on liver and kidney weight indicated no statistically significant difference ($p<0.05$) between groups, suggesting BIDC doses did not markedly alter liver and kidney weights of rats (Table 2).

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Biochemically, BIDC at 2000 mg/kg revealed no significant changes ($p > 0.05$) in cholesterol (TC), high-density lipoprotein cholesterol levels (HDL-C), but decreased ($p<0.05$) triglycerides, while increasing low-density lipoprotein cholesterol levels (LDL-C) compared to the control (Table 3). Lowered TG at 1000mg/kg could be beneficial for metabolic health, but elevated LDLC is a concern for cardiovascular risk.

Table 1: Effect of Bread Improver Dough Conditioner on Body Weight of Rats

Groups	Initial body weight (g)	Final body weight (g)	Change in body weight (g)	% Change in body weight
Normal	168.33 ± 0.67^{a}	212.00 ± 2.08^{a}	43.67 ± 1.45^{a}	20.6 ± 0.49^{a}
250 mg/kg BIDC	161.00 ± 6.25^{a}	203.33 ± 6.89^{ab}	42.33 ± 0.67^{ab}	20.87 ± 0.41^{a}
1000 mg/kg BIDC	162.00 ± 2.65^{a}	203.00 ± 5.68^{ab}	41.00 ± 3.06^{ab}	20.17 ± 0.93^{a}
2000 mg/kg BIDC	165.00 ± 2.08^{a}	198.67 ± 5.21^{bc}	33.67 ± 4.91^{abc}	16.83 ± 2.12^{ab}

Results are presented as means ± SEM. The mean values in the same column having different superscript letter(s) are significantly different ($p < 0.05$).

Table 2: Effect of Bread Improver Dough Conditioner on Organ weight of rats

Groups	Liver weight (g)	Kidney weight (g)
Normal diet	6.13 ± 0.39^{ab}	1.83 ± 0.18^{a}
250 mg/kg BIDC	6.57 ± 1.04^{ab}	1.23 ± 0.15^{ab}
1000 mg/kg BIDC	5.70 ± 0.17^{ab}	1.23 ± 0.09^{ab}
2000 mg/kg BIDC	6.00 ± 0.31^{ab}	1.57 ± 0.21^{ab}

Results are presented as means ± SEM. The mean values in the same column having different superscript letter(s) are significantly different ($p < 0.05$).

The physiological function of LDL particles is to move cholesterol to peripheral tissues although, when present in excessive concentrations, LDL-C infiltrates and accumulates within the subendothelial space of arterial walls.[32] This retained LDL becomes modified through oxidation, triggering a potent pro-inflammatory response that recruits monocytes, which differentiate into macrophages and engulf the lipoproteins to become lipid-laden foam cells, the hallmark cellular component of the earliest atherosclerotic lesion, the fatty streak.[33] The progression from a simple fatty streak to a complex, advanced atherosclerotic plaque is directly driven by the continued elevation of plasma LDL-C levels.[34] Within the arterial intima, the ongoing accumulation of foam cells, proliferation of smooth muscle cells, and deposition of extracellular matrix form a fibroatheroma that progressively narrows the arterial lumen and impairs blood flow.[33] The clinical implication of this process is most evident in the rupture or erosion of these advanced plaques, which exposes thrombogenic material to the bloodstream and can lead to acute occlusion via thrombosis, manifesting as myocardial infarction or ischemic stroke.[35]

All BIDC groups showed mildly elevated ALT compared to normal control, but these differences not statistically significant (Table 4). The 1000 mg/kg BIDC group showed the highest aspartate aminotransferase (AST) levels, followed by 250 mg/kg BIDC and then 2000 mg/kg BIDC. From the results, mid doses are shown to elevate AST levels, causing potential liver stress such as inflammation or mild toxicity. Similarly, it was observed that sodium benzoate caused derangement of liver function status, indicated by a significant increase in serum AST and ALT.[36] Nonetheless, BIDC partially reversed this effect though levels remained above normal. The 2000 mg/kg BIDC showed lower AST than 1000 mg/kg, suggesting a non-linear or adaptive response. Elevated AST (especially at 1000mg/kg) warrants caution, as AST is also found in muscles/heart. ALT and AST should not be increased in the blood; signs of their increase are signs of liver damage.[37] Nevertheless, these findings were not significant in the histopathology results.

Table 3: Effect of Bread Improver Dough Conditioner on Lipid Profile of Rats

Group	TC (mmol/l)	HDLC (mmol/l)	TG (mmol/l)	LDLC (mmol/l)
Normal diet	0.79 ± 0.81^{bc}	0.72 ± 0.09^{abc}	0.85 ± 0.04^{a}	0.17 ± 0.02^{d}
250 mg/kg BIDC	0.84 ± 0.09^{bc}	0.89 ± 0.08^{ab}	0.87 ± 0.07^{a}	0.15 ± 0.01^{d}
1000 mg/kg BIDC	0.85 ± 0.11^{bc}	0.65 ± 0.04^{abc}	0.36 ± 0.09^{c}	0.40 ± 0.00^{b}
2000 mg/kg BIDC	0.83 ± 0.05^{bc}	0.76 ± 0.18^{abc}	0.48 ± 0.11^{bc}	0.33 ± 0.04^{bc}

Results are presented as means ± SEM. The mean values in the same column having different superscript letter(s) are significantly different ($p < 0.05$).

Table 4: Effect of Bread Improver Dough Conditioner on Liver Function

GROUP	ALT (U/l)	AST (U/L)
Normal diet	14.33 ± 2.026^{b}	57.67 ± 1.83^{c}
250 mg/kg BIDC	21.33 ± 2.96^{ab}	79.67 ± 9.33^{bc}
1000 mg/kg BIDC	20.33 ± 1.76^{ab}	94.67 ± 6.44^{ab}
2000 mg/kg BIDC	18.00 ± 1.53^{ab}	68.00 ± 7.22^{bc}

Results are presented as means ± SEM. The mean values in the same column having different superscript letter(s) are significantly different ($p < 0.05$).

Table 5: Effect of Bread Improver Dough Conditioner on Kidney Function

Group	Creatinine (µmol/l)	Urea (mmol/l)
Normal diet	13.33 ± 3.33^{a}	3.70 ± 0.49^{ab}
250 mg/kg BIDC	17.33 ± 2.67^{a}	4.30 ± 1.33^{ab}
1000 mg/kg BIDC	18.33 ± 7.33^{a}	3.20 ± 0.85^{b}
2000 mg/kg BIDC	24.33 ± 1.76^{a}	3.77 ± 1.19^{ab}

Results are presented as means ± SEM. The mean values in the same column having different superscript letter(s) are significantly different ($p < 0.05$).

Table 5 shows creatinine levels, highest at 2000 mg/kg BIDC, followed by 1000 mg/kg/kg BIDC then 250 mg/kg BIDC. It further shows a dose-dependent increase in creatinine, with 2000mg/kg BIDC showing the most pronounced elevation with all values being statistically similar, but the trend suggests potential kidney strain at higher doses. Urea levels show no consistent trend as 250 mg/kg BIDC slightly increased urea, while 1000 mg/kg decreased it. This was observed when an increment in creatinine and urea plasma levels of experimental animals in response to sodium nitrite treatment as food added substances. Creatinine rise at high doses of BIDC warrants caution, as it may indicate early kidney dysfunction, a sign of reduced kidney filtration. It was confirmed statistically that rising serum creatinine levels strongly correlate with declining kidney function. [38]

Table 6: Effect of Bread Improver Dough Conditioner on Antioxidant Activity

Groups	SOD (mg/kg/dl)	Catalase (mg/kg/dl)
Normal diet	312.10 ± 1.74[b]	38.12 ± 1.74[a]
250 mg/kg BIDC	312.10 ± 2.31[b]	43.37 ± 2.93[a]
1000 mg/kg BIDC	337.10 ± 4.04[a]	28.94 ± 2.70[b]
2000 mg/kg BIDC	340.27 ± 5.78[a]	23.28 ±3.36[b]

Results are presented as means ± SEM. The mean values in the same column having different superscript letter(s) are significantly different ($p < 0.05$).

Table 6 shows a dose-dependent increase in superoxide dismutase (SOD) activity, with 1000 and 2000 mg/kg being significantly increased compared to the control, suggesting BIDC triggered this key antioxidant enzyme activity, possibly to ameliorate oxidative stress initiated by BIDC. SOD increased at high doses, indicating enhanced superoxide radical scavenging.[39] There was an increase in catalase while SOD decreased, which is a sign that oxidative stress has been induced. This is in line with the discovery that synthetic foods such as antioxidant tert-butylhydroquinone may exhibit dose-dependent effects on oxidative stress while low doses may mildly boost antioxidant defenses.[40]

The 250 mg/kg/kg BIDC showed increased catalase activity, although the 1000 and 2000 mg/kg BIDC showed decreased catalase activity compared to the control. Catalase activity is lowered at higher doses, potentially impairing hydrogen peroxide (H_2O_2) breakdown.[41] Low dose of BIDC mildly boosts catalase (which is seemingly beneficial) while 1000–2000 mg/kg/kg BIDC showed mixed effects by increasing SOD but lowering catalase, suggesting altered redox balance. Therefore, BIDC may upregulate SOD to compensate for oxidative stress but overwhelm catalase capacity at high doses. Catalase suppression could lead to H_2O_2 accumulation, triggering cellular damage.[38]

The hematology results showed a significant increase ($p>0.05$) in platelet counts was recorded for 2000 mg/kg BIDC, but no significant changes ($p>0.05$) for white blood cells, red blood cells, hemoglobin and hematocrit levels (Table 7a-c). The non-significant changes in the haematocrit (or packed cell volume) levels is in contrast to findings of,[42]who discovered that sodium benzoate consumed at high doses can induce anaemia, this was observed in decreased RBC levels after sodium benzoate was consumed in high doses. Mean corpuscular hemoglobin (MCH, pg) and mean corpuscular volume (MCV, fL) for 1000 mg/kg BIDC marked an increase, indicating larger RBCs (macrocytosis). At 2000 mg/kg BIDC, there was a decrease, suggesting smaller RBCs (microcytosis). For MCH, 1000 mg/kg BIDC showed the highest MCH values, aligning with macrocytic changes. The 1000 mg/kg BIDC may alter RBC morphology, leading to macrocytosis, indicating nutrient interference (e.g., BIDC mimicking B12/folate) or oxidative stress.

The red cell distribution width (RDW-SD) showed a significant decrease at 1000 mg/kg and 2000 mg/kg BIDC administration. Platelet count (PLT) treated groups showed elevated platelet levels across all treated groups. Platelet distribution width (PDW) and Mean platelet volume (MPV) showed minimal changes across treated groups. The 1000 mg/kg BIDC showed the lowest PDW, indicating a more homogeneous platelet size. Reduced RDW in high-dose groups suggests more uniform red blood cell size, possibly due to suppressed erythropoietic variability or oxidative stress stabilization. BIDC doses markedly increase PLT, suggesting thrombopoietic stimulation or inflammation.[43] The 2000 mg/kg BIDC had the highest PLT count (768 mcL) and lowest PDW, suggesting enhanced platelet production. The 1000–2000mg/kg BIDC reduced RDW, implying stabilized erythropoiesis or oxidative stress management, which can be linked to SOD increase in Table 6. Previous studies have shown that PLT elevation mirrors thrombopoietin agonists or inflammation-driven thrombopoiesis.[44] Toxic substances or chemicals tend to negatively decrease the levels of hematological parameters;[45] however, the BIDC in the concentration measured was less toxic.

In Figure 1A, the normal control showed normal central venules, hepatocytes, and sinusoids indicated by white, blue and slender arrows, respectively, while the liver of rats given 250 and 1000 mg/kg BIDC showed normal central venules and hepatocytes; the sinusoids appeared mildly infiltrated by inflammatory cells (Figure 1B & C). Also, the sinusoids of the livers of 2000 mg/kg rats were mildly infiltrated by inflammatory cells (Figure 1D).

Table 7a: Effect of Bread Improver Dough Conditioner on Hematological Parameters

GROUP	WBC10^9/L	RBC 10^12/L	HGB/ DI	HCT %
Normal	10.09 ± 0.04[cb]	7.20 ± 0.46[a]	12.97 ± 0.62[a]	48.57 ± 1.78[bc]
250 mg/kg BIDC	15.48 ± 1.05[a]	7.24 ± 0.56[a]	12.80 ± 0.95[a]	47.5± 0.53[ba]
1000 mg/kg BIDC	9.19 ± 0.27[cb]	6.80 ± 0.46[a]	13.37 ±0.03[a]	51.60 ± 1.27[c]
2000 mg/kg BIDC	8.67 ± 0.46[bc]	7.44 ± 0.18[a]	13.90 ± 0.35[a]	47.90 ± 1.25[bc]

Results are presented as means ± SEM. The mean values in the same column having different superscript letter(s) are significantly different ($p < 0.05$).

Table 7b: Effect of Bread Improver Dough Conditioner on Hematological Parameters

GROUP	MCV (FL)	MCH (pg)	RDWSD (FL)	RDWCV (%)
Normal	68.47 ± 3.77[bc]	18.00 ± 0.12[ab]	50.93 ± 10.63[a]	22.60 ± 2.41[a]
250 mg/kg BIDC	66.2 ± 4.58[bc]	17.7 ± 0.29[b]	50.50 ± 9.61[a]	22.80 ± 1.72[a]
1000 mg/kg BIDC	80.17 ± 4.53[c]	20.13 ± 1.33[a]	35.27 ± 1.19[a]	17.13 ± 0.70[a]
2000 mg/kg BIDC	64.37 ± 0.37[bc]	18.67 ± 0.12[ab]	36.17± 2.79[a]	18.13 ± 1.63[a]

Results are presented as means ± SEM. The mean values in the same column having different superscript letter(s) are significantly different ($p < 0.05$).

Table 7c: Effect of Bread Improver Dough Conditioner on Hematological Parameters

GROUPS	PLT (mcL)	MPV (fl)	PDW%
Normal	655.67 ± 53.54[bc]	7.80 ± 0.06[ab]	8.50 ± 0.26[ab]
250 mg/kg BIDC	768.00 ± 62.45[ab]	7.70 ± 0.45[ab]	8.30 ± 0.75[ab]
1000 mg/kg BIDC	641.00 ± 43.52[bc]	7.43 ± 0.12[b]	7.62 ± 0.12[b]
2000 mg/kg BIDC	881.00 ± 30.81[a]	7.63 ± 0.20[bc]	8.17 ± 0.44[ab]

Results are presented as means ± SEM. The mean values in the same column having different superscript letter(s) are significantly different ($p < 0.05$).

In Figure 2A & B, indicating control and 250 mg/kg rat kidneys, the renal cortex with normal glomeruli shows normal mesangial cells and capsular spaces (white arrow), and normal renal tubules lined by normal cuboidal epithelial cells (blue arrow). The difference observed between the kidneys of the control and the 1000 and 2000 mg/kg (Figure 2C & D) was the renal tubules with narrowing of the lumen (green arrow),

and the interstitial spaces with mild infiltration of inflammatory cells (slender arrow). Histopathology also assesses the effects of toxins or drugs on liver and kidney tissues.[46] Liver histology evaluates conditions like cirrhosis and steatosis, while kidney histology examines glomerular and tubular damage.[47] The liver and kidney histopathological examination revealed no apparent abnormalities in the cellular architecture of these vital organs; the treatment did not adversely affect the morphology of the vital organs. However, the sinusoids appeared mildly infiltrated by inflammatory cells in some cases.

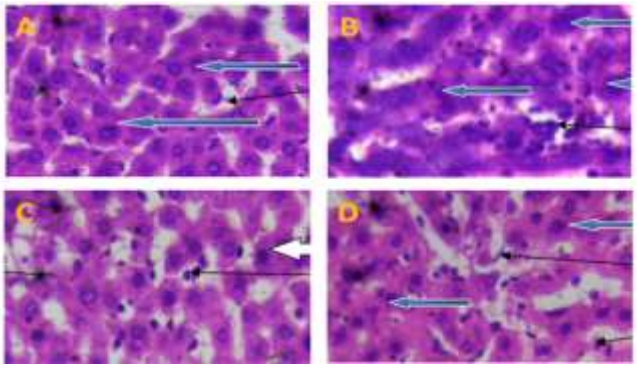

Figure 1: Histopathology of the liver (x400). A- Normal control; B- 250 mg/kg BIDC; C- 1000 mg/kg BIDC; D- 2000 mg/kg BIDC

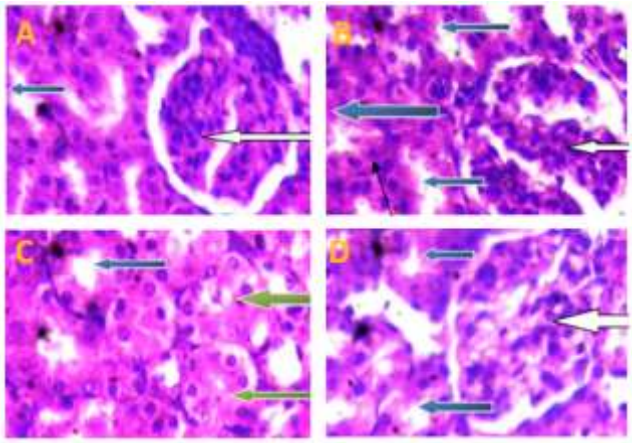

Figure 2: Histopathology of the kidney (x400). A- Normal control; B- 250 mg/kg BIDC; C- 1000 mg/kg BIDC; D- 2000 mg/kg BIDC.

Conclusion

Generally, the BIDC appears to be safe when consumed in low doses. However, high doses have been shown to induce toxicity, specifically reducing final body weight and increasing LDL-C levels in rats. Notwithstanding, the histopathology studies revealed no significant organ damage despite the potential toxicity of BIDC.

Conflict of interest

The authors declare no conflict of interest

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them

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