Original article

# Assessment of Acute Toxicological Effects of a Household Detergent on Hematological, Biochemical, and Histological Parameters in Mice

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## ABSTRACT

**Background:** This study investigated the acute oral toxicity of the widely used VIVA PLUS® detergent in BALB/c mice to address significant public health concerns regarding accidental ingestion.

**Methods:** Four groups of 5 mice of both sexes, averaging 21-28 g, were administered oral graded doses (1000, 2000, and 5000 mg/kg) daily for 14 days.

**Results:** Results revealed a dose-dependent increase in mortality from 40% to 80%, with a calculated median lethal dose ($LD_{50}$) of 1,414 mg/kg, thus classifying the detergent as moderately toxic. Observed clinical signs of toxicity included severe piloerection, lethargy, respiratory distress, and diarrhea, which intensified with higher doses. Hematological analysis demonstrated a significant ($p = 0.0014$) inflammatory response, evidenced by elevated white blood cell counts, alongside progressive anemia and a decline in platelet counts. Serum biochemistry confirmed substantial organ damage, with dose-dependent elevations ($p = 0.0011$) in liver enzymes (ALT, AST, ALP) and kidney markers (urea, creatinine), coupled with reduced total protein and albumin. Histopathological examination provided conclusive evidence of systemic injury, revealing severe lesions such as periportal necrosis in the liver, acute tubular necrosis and cast formation in the kidneys, and ulceration with hemorrhage in the gastric mucosa.

**Conclusion:** These findings demonstrate that acute oral exposure to VIVA PLUS® detergent induces significant, dose-dependent hematological, biochemical, and histopathological alterations, leading to multi-organ failure. This research underscores the critical need for enhanced safety protocols, clear public health advisories, and stringent regulatory oversight to mitigate the risks of accidental poisoning associated with common household detergents.

***Keywords:*** *Viva Plus®, Hematology, BALB/c Mice, Histopathology, Oral Toxicity, $LD_{50}$*

## INTRODUCTION

Household detergents have become an important part of daily life, providing an efficient and convenient means of maintaining hygiene. They are used in almost every home, institution, and industry for cleaning purposes, from laundry and dishwashing to surface cleaning (Yahaya et al., 2019) However, despite their usefulness, detergents contain chemical compounds primarily surfactants, builders, enzymes, and bleaching agents that can pose significant health and environmental hazards when misused or accidentally ingested (Bates, 2017). The growing rate of detergent-related poisoning incidents, particularly in developing countries, provides the urgent need for scientific evaluation of their safety profiles.

In Nigeria, Viva Plus® detergent has gained enormous popularity due to aggressive advertising and its perceived effectiveness. According to Abugu et al., (2025), social media campaigns and local marketing strategies have significantly influenced consumer preference for Viva Plus® among students and households. However, this increased patronage has not been matched with adequate awareness of the potential toxicological risks associated with accidental or deliberate ingestion, especially by children and domestic animals. While detergents are marketed as safe cleaning products, their chemical constituents can cause systemic toxicity when ingested, inhaled, or absorbed through mucous membranes (Bates, 2017).

Detergents typically contain anionic surfactants such as linear alkylbenzene sulfonates (LAS), non- ionic surfactants like ethoxylates, and various stabilizers and colorants (Benson et al., 2011). When ingested, these chemicals can disrupt biological membranes, leading to hemolysis, gastrointestinal irritation, hepatic stress, and renal impairment (Yahaya et al., 2011). Experimental studies in laboratory animals have shown that detergents can induce oxidative stress, enzyme elevation, and histopathological alterations in critical organs such as the liver and kidneys (Akhila et al., 2007; Ali, 2012; Benson et al., 2011). Despite these findings, relatively few studies have focused on local detergent available in Nigerian markets, leaving a significant knowledge gap regarding their potential health implications.

### Accidental and Environmental Exposure to Detergents

Accidental exposure to detergents remains a common occurrence worldwide, especially in homes with children, poorly labeled containers, or improper storage practices. According to Bates (2017), detergent ingestion is one of the leading causes of chemical poisoning in companion animals and children under the age of five. Symptoms often include vomiting, diarrhea, lethargy, and respiratory distress signs that may mimic other gastrointestinal or metabolic disorders.

In low- and middle-income countries, such exposures are often underreported due to limited access to poison control centers and inadequate public awareness. The problem is compounded by orthographical and linguistic deviations in labeling and outdoor advertisements, which can misinform or confuse non-English-speaking populations. Umar et al. (2021) observed that improper orthography and grammar on Hausa billboards and product labels can alter meaning and reduce comprehension, thereby increasing the risk of product misuse. Such findings are particularly relevant in northern Nigeria, where Viva Plus® is widely distributed and advertised in both English and Hausa languages.

Accidental poisoning incidents are not limited to children or pets alone. Adults are also at risk, especially those who mix cleaning agents carelessly. Minami et al. (1992) documented a case in Japan where the combination of household detergents in a poorly ventilated toilet generated toxic fumes, leading to severe respiratory distress and environmental hazards. Their simulation experiments demonstrated that simple household chemicals, when improperly combined or used in confined spaces, could create lethal conditions. This example highlights the underestimated risks of common detergents and underscores the importance of scientific toxicological evaluation to guide safe handling and usage.

While detergents are widely regarded as safe when used correctly, the potential for harm increases significantly with misuse or exposure beyond normal domestic levels. Unfortunately, most consumers are unaware that detergents can exert systemic toxicity when ingested or inhaled in sufficient quantities. Cases of accidental ingestion in humans and animals often result in mucosal irritation, vomiting, abdominal pain, and, in severe cases, hepatic and renal failure (Bates, 2017; Ali, 2012).

Despite the ubiquity of detergent use in Nigeria, there is a striking paucity of data on the acute toxicity and median lethal dose ($LD_{50}$) of powdered versions of commonly used brands. Without such information, it becomes difficult to classify these products under the internationally accepted toxicity scales, such as those recommended by the Organization for Economic Co-operation and Development (OECD). Moreover, understanding the pathophysiological changes caused by detergent ingestion is vital for medical management, public health interventions, and consumer safety regulation.

The choice of Viva Plus® detergent for this study is particularly justified by its dominance in the Nigerian market and its increasing household use, as reported by Abugu et al., (2025). Given that detergent toxicity can vary depending on the formulation and concentration of surfactants, additives and the dose ingested, it is critical to evaluate the specific biological impact of this brand under controlled laboratory conditions. Determining its $LD_{50}$ and associated clinical, hematological, and histopathological changes in a standardized animal model provides a reliable scientific foundation for risk assessment.

### Choice of Animal Model

Using BALB/c mice also facilitates comparison with previous findings in detergent toxicity research, allowing for a better understanding of the potential mechanisms of organ injury (Barrios et al., 2009). The controlled laboratory setting ensures minimal confounding variables, thus providing reproducible and interpretable results that can be extrapolated to environmental and both human and animal health contexts.

This research holds both scientific and societal relevance. From a scientific standpoint, it contributes to the growing body of literature on detergent toxicology, offering novel data on a locally manufactured and widely consumed product. By determining the $LD_{50}$ and identifying dose-dependent physiological and histopathological changes, this study provides evidence-based insights into the safety threshold of Viva Plus® detergent. Such data can inform policymakers, manufacturers, and health professionals in implementing safety labeling, packaging guidelines, and risk communication strategies.

From a public health perspective, the study draws attention to the hidden dangers of household cleaning products, especially in communities with limited literacy or health education. As Umar et al., (2021) highlighted, linguistic inconsistencies in local advertising can undermine the effectiveness of warning labels, making it easier for consumers to misinterpret dosage instructions or safety symbols. The findings of this study therefore have the potential to inform health education campaigns and product communication standards that reduce the incidence of accidental poisoning.

Additionally, this study provides baseline data for further research on the chronic effects and environmental impact of detergents. As detergents often find their way into water bodies through domestic effluents, understanding their acute toxicity in mammalian systems is a crucial step toward evaluating ecological risks and bioaccumulation potential. This aligns with the growing global concern about the long-term consequences of synthetic surfactants on both human health and aquatic ecosystems.

Detergents such as Viva Plus® are commonly used household cleaning agents. According to Aspirat Nigerian Limited (2025), Viva Plus® detergent consists primarily of anionic and nonionic surfactants, sodium carbonate, enzymes, optical brighteners, and fragrance compounds, which enhance its cleaning performance but may pose biological risks with prolonged exposure. Although essential for maintaining hygiene, detergents are not without toxic potential. Accidental ingestion by animals may occur from leftover detergent-contaminated water after laundry, particularly in remote communities where awareness of such hazards is limited, coupled with inadequate consumer awareness and inconsistent labeling, this highlights the need for toxicological evaluation (MacKendrick, 2018). Previous studies have reported that detergents can cause organ damage and biochemical alterations; however, data specific to Nigerian formulations remain limited (Yahaya et al., 2011). Therefore, this study investigates the acute oral toxicity and organ-level effects of Viva Plus® detergent in BALB/c mice to bridge this knowledge gap and enhance public health awareness.

Ultimately, the findings will support improved risk communication, regulatory frameworks, and public education on detergent safety helping to prevent avoidable

cases of poisoning and ensuring that cleaning products serve their intended purpose without compromising health or life.

## METHODOLOGY

### Experimental Animals

BALB/c mice were selected as the experimental model for this study due to their well-characterized immune, hematological, and hepatic profiles. They are among the most frequently used murine strains in toxicological and pharmacological research because of their predictable responses and stable physiological parameters (Barrios et al., 2009; Laber et al., 2008). Furthermore, previous studies have established their suitability for assessing acute and subacute toxicity of chemicals, including surfactants and detergents (Akhila et al., 2007; Benson et al., 2011).

Twenty adult BALB/c mice aged between 8-10 weeks, weighing 21-28 g were procured for this study, and the mice are allowed to acclimatized for one week at animal house of Department of Veterinary Physiology and Biochemistry, Faculty of Veterinary Medicine University of Maiduguri, Nigeria, under standard laboratory conditions (temperature 25 ± 2°C, 12 h light/dark cycle) with free access to commercial pellets (Topfeeds, Oyo State, Nigeria) and water ad libitum, as described by Laber et al. (2008). The strain was selected for its well-characterized immune and hepatic physiology (Meyer et al., 1979; Barrios et al., 2009).

### Experimental Design, Preparation of Viva Plus® Solutions and Administration

Commercial Viva Plus® detergent was purchased from a local market in Maiduguri, Nigeria. Each day, fresh dosing solutions were prepared by accurately weighing and dissolving the detergent powder in distilled water to obtain the desired concentrations. The mixtures were thoroughly stirred to ensure even distribution before administration.

The experimental animals were randomly divided into four groups (n = 5) to obtained a statistical power. Group A (control) received only distilled water, while Groups B, C, and D were orally administered Viva Plus® detergent at doses of 1000, 2000, and 5000 mg/kg body weight, respectively. The dosing regimen followed the OECD guideline 425 (Sachana et al., 2022) and the procedures, as was described by Akhila et al., (2007) and Chinedu et al., (2013). Each mouse received 2 mL of the freshly prepared solution once daily for 14 consecutive days using a calibrated oral gavage needle. The selected concentrations were based on preliminary range-finding tests and supported by previous studies on acute detergent toxicity (Bates, 2017; Minami et al., 1992).

### Sample Collection

Tissue test samples were collected at the end of the exposure period or immediately upon manifestation of severe clinical signs. Mice were euthanized by cervical dislocation under light anesthesia (Cartner et al., 2007). Blood samples were collected via cardiac puncture, as recommended by Schnell et al. (2002), to avoid stress-related biochemical alterations. The liver, kidneys and stomach were excised, weighed, and preserved in 10% neutral-buffered formalin for histopathological analysis, following the procedure of Ali (2012) and Benson et al. (2011).

Clinical signs such as piloerection, lethargy, respiratory distress, and diarrhea were recorded according to. Blood samples were collected from direct cardiac puncture after euthanasia at the end of the experiment. Mice that exhibit severe toxicity signs were humanely euthanized, and blood was collected in EDTA coated bottles immediately for hematological and biochemical analyses.

### Determination of $LD_{50}$

The median lethal dose ($LD_{50}$) was estimated by Lorke (1983) method of dose–mortality data as outlined by Akhila et al. (2007) and Ali (2012). Where The $LD_{50}$ was estimated as the geometric mean of the lowest dose that caused death and the highest dose that did not cause death, using this formula:

where:

$D_0$ = highest dose with no mortality

$D_{100}$ = lowest dose with mortality.

Mortality was recorded daily, and the $LD_{50}$ value was expressed in mg/kg body weight.

### Hematological and Biochemical Analysis

Whole blood was analyzed using Sysmex KX-21N automated hematology analyzer for WBC, RBC, Hb, PCV, MCV, MCH, and platelets following Barrios et al. (2009) and Ike et al. (2010). Serum was separated for biochemical

assays (ALT, AST, ALP, urea, creatinine, total protein, and albumin) using standard spectrophotometric methods (Clinkenbeard et al., 2019; Shamaki et al., 2009).

### Histopathological Examination

After euthanasia, the liver, kidney, and stomach were excised, rinsed in saline, and fixed in 10% neutral buffered formalin. Tissues were processed, sectioned at 5 µm, and stained with hematoxylin and eosin for microscopic examination following Benson et al. (2011).

### Statistical Analysis

Statistical analysis was performed using GraphPad Prism version 9. In Groups C and D, n = 4 because samples were not collected from all mice; some died, while others showing severe clinical signs, were euthanized for sample collection. After confirming data normality (Shapiro-Wilk test) and homogeneity of variance (Bartlett's test), hematological and biochemical parameters were compared across all four groups using one-way ANOVA, followed by Tukey's HSD post-hoc test for significant results ($p < 0.05$).

## RESULTS

The present study assessed the acute oral toxicity of VIVA PLUS® detergent in BALB/c mice, with emphasis on determining its median lethal dose ($LD_{50}$), identifying the pattern of clinical signs, and examining histopathological alterations in vital organs. The findings provide valuable insight into the systemic and organ-specific consequences of detergent ingestion, a growing public health and environmental concern. Acute oral exposure to Viva Plus® detergent produced dose-dependent mortality, with survival rates decreasing from 100% in controls to 20% at 5000 mg/kg as presented in table 1. Prominent clinical signs included piloerection, lethargy, reduced grooming, and respiratory distress, which intensified with increasing doses (Table 2). Hematological evaluation revealed significant increases in WBC counts and progressive reductions in RBC, Hb, PCV, and platelet levels as presented in table 3. Serum biochemical analysis showed significant, dose-dependent elevations in ALT, AST, ALP, urea, and creatinine, accompanied by reduced total protein and albumin concentrations (Table 4). The estimated oral $LD_{50}$ of Viva Plus® detergent was 1,414 mg/kg body weight.

Mortality was recorded for 14 days after a single oral administration. The $LD_{50}$ was estimated at 1,414 mg/kg body weight using linear interpolation.

Key: – = Absent; + = Mild; ++ = Moderate; +++ = Severe. Clinical signs were recorded intensively within 24 h post-administration and twice daily thereafter.

($p < 0.05$), while MCH and MCHC decreased ($p < 0.05$), indicating macrocytic–hypochromic anemia. The hematological alterations suggest bone marrow suppression or oxidative injury to circulating erythrocytes induced by detergent exposure.

| Group | Dose (mg/kg) | Survivors | Deaths | Mortality (%) | Survival (%) |
|---|---|---|---|---|---|
| A (Control) | 0 | 5/5 | 0/5 | 0 | 100 |
| B (Low) | 1000 | 3/5 | 2/5 | 40 | 60 |
| C (Medium) | 2000 | 2/5 | 3/5 | 60 | 40 |
| D (High) | 5000 | 1/5 | 4/5 | 80 | 20 |

*Table 1: Mortality and Survival Rates Following Acute Oral Exposure to VIVA PLUS® Detergent*

| Clinical sign | Control 0 mg/kg | Low 1000 mg/kg | Medium 2000 mg/kg | High 5000 mg/kg |
|---|---|---|---|---|
| Piloerection | – | + | ++ | +++ |
| Lethargy | – | + | ++ | +++ |
| Reduced grooming | – | + | ++ | +++ |
| Respiratory distress | – | – | + | ++ |
| Diarrhea | – | – | – | + |

*Table 2: Summary of Observed Clinical Signs of Toxicity in Mice Exposed to VIVA PLUS®*

| Parameter | Control 0 mg/kg | Low 1000 mg/kg | Medium 2000 mg/kg | High 5000 mg/kg |
|---|---|---|---|---|
| WBC (×10□/L) | 7.82 ± 0.52 | 8.40 ± 0.64 | 10.26 ± 0.72 | 11.38 ± 0.61 |
| RBC (×10¹²/L) | 7.01 ± 0.31 | 6.94 ± 0.28 | 5.60 ± 0.32 | 4.81 ± 0.27 |
| Hb (g/dL) | 13.80 ± 0.56 | 13.42 ± 0.49 | 11.65 ± 0.53 | 10.20 ± 0.46 |
| PCV (%) | 41.6 ± 1.8 | 39.8 ± 1.6 | 34.2 ± 1.5 | 31.4 ± 1.2 |
| MCV (fL) | 59.3 ± 2.3 | 57.3 ± 2.2 | 61.1 ± 2.1 | 65.2 ± 2.8 |
| MCH (pg) | 19.7 ± 0.8 | 19.4 ± 0.7 | 20.8 ± 0.9 | 21.2 ± 0.9 |
| Platelet (×10□/L) | 684 ± 36 | 610 ± 31 | 492 ± 28 | 415 ± 24 |

*Table 3: Hematological Parameters of Mice Following Acute Oral Exposure to VIVA PLUS®*

| Parameter | Control 0 mg/kg | Low 1000 mg/kg | Medium 2000 mg/kg | High 5000 mg/kg |
|---|---|---|---|---|
| ALT (μ/L) | 42.3 ± 3.6 | 58.4 ± 4.1 | 75.9 ± 5.0 | 92.6 ± 6.2 |
| AST (μ/L) | 86.2 ± 5.4 | 101.7 ± 6.3 | 126.5 ± 7.8 | 139.4 ± 8.1 |
| ALP (μ/L) | 212 ± 15 | 245 ± 18 | 282 ± 19 | 318 ± 21 |
| Urea (mmol/L) | 6.24 ± 0.41 | 7.85 ± 0.46 | 9.72 ± 0.57 | 10.61 ± 0.63 |
| Creatinine (μmol/L) | 62.8 ± 3.5 | 74.2 ± 4.1 | 91.3 ± 4.7 | 104.6 ± 5.2 |
| Total protein (g/dL) | 6.84 ± 0.28 | 6.72 ± 0.26 | 6.10 ± 0.24 | 5.72 ± 0.23 |
| Albumin (g/dL) | 4.11 ± 0.19 | 3.88 ± 0.17 | 3.41 ± 0.15 | 3.12 ± 0.14 |

*Table 4: Effect of Oral Administration of Viva Plus® Detergent on Hepatic Enzyme Activities and Total Bilirubin Concentrations in BALB/c Mice after 14 Days*

## DISCUSSION

The calculated $LD_{50}$ value of 1,414 mg/kg body weight indicates that VIVA PLUS® detergent possesses a moderate level of acute toxicity, consistent with the Globally Harmonized System (GHS) classification, where substances with $LD_{50}$ values between 500 mg/kg and 5,000 mg/kg are considered moderately toxic (Misik et al., 2012). This finding aligns with previous reports by Yahaya et al., (2011) and Sobrino-Figueroa (2018), who described similar toxicity profiles in animals exposed to detergent-based formulations.

The pattern of mortality none in the control group but rising progressively from 40% at 1,000 mg/ kg to 60% and 80% at 2,000 mg/kg and 5,000 mg/kg, respectively demonstrates a clear dose- dependent response, a hallmark of surfactant-induced toxicity (Abel, 1974). Increasing lethality with higher doses suggests that detergent constituents,

particularly anionic surfactants, interfere with normal cellular metabolism through membrane disruption, oxidative stress, and inhibition of enzymatic activities (Basketter et al., 2012).

The clinical and behavioral signs also exhibited a dose-related pattern. Control mice remained normal, while mild piloerection, lethargy, and reduced grooming appeared at 1,000 mg/kg. At 2,000 mg/kg, these effects intensified, with additional respiratory distress and diarrhea, and were severe at 5,000 mg/kg. These manifestations corroborate previous reports of detergent exposure in animals (Day et al., 2019; Schneir et al., 2013; Banner et al., 2020). The lethargy and hypoactivity observed are indicative of central nervous system depression, possibly due to metabolic acidosis and electrolyte imbalance secondary to surfactant absorption. Respiratory distress likely results from pulmonary irritation or systemic hypoxia, while diarrhea and reduced grooming may reflect gastrointestinal discomfort and general debilitation.

Blood samples were collected from moribund animals displaying severe toxicity immediately prior to euthanasia to prevent post-mortem deterioration and obtain reliable biochemical data.

Histopathological findings provided further insight into target-organ injury. The liver exhibited dose-dependent periportal and centrilobular necrosis, vacuolar degeneration, and Kupffer-cell activation, reflecting hepatocellular injury caused by oxidative stress and surfactant-mediated membrane damage. These lesions resemble those reported in detergent-exposed rodents (Yahaya et al., 2011) and humans (Park et al., 2022). The hepatic injury may stem from the detergent's surfactant components generating reactive oxygen species and impairing antioxidant enzyme systems.

The kidneys showed degeneration and necrosis of tubular epithelial cells, glomerular congestion, and cast formation, particularly at higher doses. These lesions are consistent with acute tubular necrosis, a well-recognized outcome of detergent-induced nephrotoxicity. Similar changes have been described in experimental and clinical detergent toxicity cases (Misik et al., 2012; Park et al., 2022). The renal lesions likely result from direct cytotoxic effects of absorbed surfactants and renal ischemia secondary to circulatory disturbances.

The gastric mucosa demonstrated clear dose-related damage. At low and medium doses, mild epithelial erosion and goblet-cell hyperplasia were noted, while high doses produced epithelial necrosis, ulceration, and hemorrhage of the muscularis mucosae. These findings mirror those of Ogulur et al., (2023) and Fuchs and Ingelfinger (1954), who reported detergent-induced disruption of epithelial barriers and impairment of digestive mucosal integrity. Such lesions account for the diarrhea and reduced appetite observed in higher-dose groups.

The combination of dose-dependent mortality, clinical signs, and histopathological lesions underscores the systemic toxicity of VIVA PLUS® detergent in BALB/c mice. The observed effects are consistent with known mechanisms of surfactant toxicity, which involve disruption of phospholipid membranes, leakage of intracellular contents, oxidative damage, and necrosis in vital organs (Basketter et al., 2012). Repeated or accidental exposure could therefore have cumulative adverse effects, highlighting the importance of safe handling, proper labeling, and public education on detergent use.

From an environmental perspective, these findings echo reports that detergents cause broad- spectrum ecological toxicity, impairing enzymatic function, reproduction, and protein metabolism in aquatic organisms (Nkpondion et al., 2016; Sobrino-Figueroa, 2018). The ecological implications reinforce the need for strict regulation of detergent formulation and disposal to prevent environmental contamination.

VIVA PLUS® detergent exhibits moderate acute oral toxicity in BALB/c mice, characterized by dose-dependent clinical, biochemical, and histopathological changes in the liver, kidneys, and gastrointestinal tract. These findings align with previous research on detergent toxicity in animals and humans, showcasing the potential health hazards associated with accidental ingestion and the necessity of continued toxicological assessment of common household products to ensure consumer and environmental safety.

## CONCLUSION

Based on the finding of our study, VIVA PLUS® detergent possesses a moderate level of acute oral toxicity in BALB/c mice, with an estimated $LD_{50}$ of 1,414 mg/kg body weight according to Lorke's method. Mortality, clinical

manifestations, and histopathological lesions all followed a dose- dependent pattern, confirming systemic toxicity associated with detergent exposure. The prominent alterations included increased lethargy, respiratory distress, diarrhea, and significant hepatic, renal, and gastrointestinal damage, reflecting the disruptive effects of surfactant components on cellular integrity and organ function.

These findings align with previous reports on detergent-induced toxicity and emphasize the public health and environmental risks linked to improper handling or accidental ingestion of such products. Consequently, there is a critical need for enhanced consumer education, proper labeling, and regulatory monitoring of detergent formulations to safeguard both human, and ecological health.

### STATEMENTS AND DECLARATIONS

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**Authors' contributions:** AYG and DLM conceived and designed the work. MAI performed the statistical analysis. UAM and BUS were responsible for proofreading. DM carried out the laboratory procedures.

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