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## Research Article

# Synergistic Effects of Combined Tiger Nut, Date Fruit and Coconut Extracts on Endogenous Antioxidant Defense Systems and Oxidative Stress Regulation in Wistar Rats

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## Abstract

**Background and Objective:** Oxidative stress plays a central role in the pathogenesis of metabolic disorders, cardiovascular diseases, neurodegeneration, aging and inflammatory conditions. Natural products rich in phenolic compounds, flavonoids, vitamins and bioactive lipids have attracted considerable interest as natural antioxidants. This study evaluated the biochemical antioxidant and oxidative stress-modulatory effects of a synergistic mixture of *Cyperus esculentus* (tiger nut), *Phoenix dactylifera* (date fruit) and *Cocos nucifera* (coconut) (STDC) in male Wistar rats. **Materials and Methods:** Acute oral toxicity was assessed using Lorke's method. Fifteen male Wistar rats were randomly assigned to three groups (n = 5): A control group and two treatment groups receiving STDC at doses of 200 and 400 mg/kg body weight orally for 21 days. Serum antioxidant biomarkers, including reduced glutathione (GSH), glutathione peroxidase (GPx), glutathione-S-transferase (GST), catalase (CAT), superoxide dismutase (SOD) and malondialdehyde (MDA), were determined using standard biochemical methods. **Results:** The oral LD<sub>50</sub> of STDC was  $\geq 2404.2$  mg/kg, indicating relative safety. The STDC administration enhanced endogenous antioxidant defense by increasing CAT, SOD and GSH activities compared with the control group. The 200 mg/kg dose produced the highest GSH concentration (1.360 mg/dL), whereas CAT activity was greatest in the 400 mg/kg group. Furthermore, MDA levels were markedly reduced in both treatment groups, indicating decreased lipid peroxidation and attenuation of oxidative damage. Overall, STDC improved cellular redox status and free radical scavenging capacity. **Conclusion:** The synergistic combination of *Cyperus esculentus*, *Phoenix dactylifera* and *Cocos nucifera* exhibits potent antioxidant activity by enhancing endogenous antioxidant defenses and suppressing lipid peroxidation. These findings suggest that STDC has potential as a functional nutraceutical for the prevention and management of oxidative stress-related disorders.

**Key words:** Oxidative stress, antioxidant enzymes, glutathione, malondialdehyde, tiger nut, date fruit, coconut, redox homeostasis

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**Competing Interest:** The authors have declared that no competing interest exists.

**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Reactive oxygen species (ROS) are continuously generated during normal cellular metabolism, primarily through mitochondrial oxidative phosphorylation, NADPH oxidase activity, xanthine oxidase reactions and inflammatory processes. Although ROS serve important physiological functions in cell signalling and immune Défense, excessive ROS production overwhelms endogenous antioxidant systems, leading to oxidative stress<sup>1-3</sup>. Oxidative stress contributes to lipid peroxidation, DNA damage, protein oxidation, mitochondrial dysfunction and apoptosis, thereby promoting the development of cardiovascular diseases, diabetes mellitus, cancer, neurodegenerative disorders and aging-related pathologies<sup>4</sup>.

The mammalian antioxidant defense system comprises enzymatic antioxidants such as superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and glutathione-S-transferase (GST), as well as non-enzymatic antioxidants including reduced glutathione (GSH), vitamins C and E, carotenoids and polyphenols. Maintenance of redox balance depends on the coordinated activity of these systems<sup>5</sup>.

Tiger nut (*Cyperus esculentus*) contains significant quantities of vitamin E, phenolic compounds, flavonoids, oleic acid and dietary fiber<sup>6</sup>. Date fruit (*Phoenix dactylifera*) is rich in flavonoids, phenolic acids, carotenoids and natural sugars possessing strong antioxidant capacities<sup>7</sup>. Coconut (*Cocos nucifera*) contains medium-chain fatty acids, polyphenols, tocopherols and other bioactive compounds capable of scavenging free radicals and improving antioxidant status<sup>8</sup>.

The combination of tiger nut, date fruit and coconut may therefore provide synergistic antioxidant effects through complementary mechanisms rather than simply through the additive contribution of their individual antioxidant constituents. Their diverse bioactive compounds may simultaneously promote direct scavenging of reactive oxygen species, inhibit lipid peroxidation and enhance endogenous antioxidant defenses through redox-sensitive pathways such as the Nrf2/ARE signaling pathway. Such coordinated actions could increase the availability of reduced glutathione (GSH), enhance the activities of superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and glutathione-S-transferase (GST), while limiting oxidative damage reflected by malondialdehyde (MDA). The presence of compounds with different antioxidant properties and cellular targets may consequently provide broader and more sustained protection against oxidative stress than a single food component. This

mechanistic complementarity provides the rationale for evaluating the combined tiger nut, date fruit and coconut formulation as a potential synergistic antioxidant intervention. Therefore, this study evaluated the antioxidant and oxidative stress-modulatory effects of the synergistic mixture of tiger nut, date fruit and coconut in Wistar rats.

## MATERIALS AND METHODS

**Study area and duration:** This study was carried out at the Animal House of the Department of Pharmacology and Therapeutics, Rivers State University and the Department of Biochemistry Laboratory, Faculty of Science, Rivers State University from November 2022 to April 2023.

**Acute toxicity studies (LD<sub>50</sub>) of STDC:** The acute toxicity of synergistic mixture of *Cyperus esculentus*, *Phoenix dactylifera* and *Cocos nucifera* (STDC) using Lorke<sup>9</sup> Method as reported by Adefisayo *et al.*<sup>10</sup> was used. The Rats were divided into 2 phases of 9 and 8 rats, respectively. In the phase1 study, 9 rats were divided into 3 groups of 3 rats each and they were administered with STDC by oral gavage at doses of 10, 100 and 1000 mg/kg. In the phase2 study, 8 rats were divided into 4 groups of 2 rats each and they were administered with STDC by gavage at doses of 850, 1700, 3400 and 6800 mg/kg. The general behavior of the animals was observed for the first 1 hr, 4 hrs and hourly in a continuous, intermittent and hourly pattern, respectively for the next 24 hrs after administration. The LD<sub>50</sub> was determined using the formula:

$$LD_{50} = \sqrt{a \times b}$$

Where:

a = Least dose that killed any rat

b = Highest dose that did not kill any rat

**Measurement of body weight change:** Weekly weight measurement of animals in all groups using a digital weighing balance was done to ascertain either weight gain or weight loss.

**Experimental design:** Fifteen healthy male Albino Wistar rats weighing between of 250-300 g were procured from the animal house of the Department of Pharmacology and Therapeutics, Rivers State University, Port Harcourt, Nigeria. The animals were housed in clean plastic cages in well-ventilated housing under a 12 hrs light-dark cycle with unrestricted access to rat pellets and tap water *ad libitum*. The animals were acclimatized for 7 days.

**Ethical statement:** The animals were handled according to National Institute of Health (NIH) guidelines for care and use of experimental animals National Research Council (NRC), 2011<sup>11</sup>.

**Plant material and preparation of extract:** Fresh seeds of tiger nuts, dates and coconut were purchased from mile 1 market in Port Harcourt. Tiger nuts (400 g) were cleaned to remove impurities, washed and put in a bowl. The dates (120 g) were cut into two to remove the seeds, then washed and put in a bowl. The coconut (200 g) was removed from the shell, diced and washed. All were pulverized with a manual blender, adding 150 mL of water until a uniformed mixture was obtained. The mixture was filtered using a sieve and the resulting filtrate was put into a bottle until use. This synergistic mixture (STDC) was prepared daily for the 21 days of administration.

**Experimental protocol:** The acclimatized animals were allotted to Group 1 (Control) and were administered with normal rat feed and distilled water, Group 2 STDC were administered 200 mg/kg of the synergistic mixture (tiger nut, dates and coconut) and Group 3 STDC were administered 400 mg/kg of the synergistic mixture (tiger nut, dates and coconut):

- **Group 1(Control):** Feed+water *ad libitum*
- **Group 2 STDC:** Feed+water *ad libitum*+200 mg/kg of STDC
- **Group 3 STDC:** Feed+water *ad libitum*+400 mg/kg of STDC

The administration in both groups 2 and 3 was done orally using an oral gavage tube. The administration lasted for 21 days and animals were sacrificed.

**Collection of samples (blood):** Sacrifice was done in three batches, the first was carried out after 7 days, the second after 14 days and the third after 21 days. The animals were sacrificed, followed by decapitation and dissection. Blood samples were collected through cardiac puncture and transferred into non-vacuum collection blood tubes (plain tubes 5 mL) for Antioxidant analysis and analyzed uncentrifuged.

**Antioxidant analysis:** Antioxidant analysis (GSH, GST, GPx, Catalase, Malondialdehyde and SOD) was carried out as reported in methods used by Odinga and Nwaokezi<sup>12</sup> and Gabriel-Brisibe *et al.*<sup>13</sup>.

**Statistical analysis:** The Descriptive results were expressed as Mean±Standard Deviation. Data were analyzed using one-way analysis of variance followed by *post hoc* test using Tukey's test and p-value less than 0.05 was considered statistically significant. The statistical analysis was performed with the aid of IBM SPSS, Version 27.

## RESULTS AND DISCUSSION

**Acute oral toxicity test (LD<sub>50</sub>) of STDC:** Orally administrated STDC at concentrations between 10-1700 mg/kg showed no toxicity in the experimental rats. Symptoms of diarrhea, fatigue and 50% mortality were detected in the rats administered 3400 and 6800 mg/kg of STDC. The other 50% were administered 100 mg/kg of lime fruit juice, which resuscitated them. Variation in weight was a prominent feature across the experimental rats in the two phases of the experiment. The oral LD<sub>50</sub> of STDC was determined to be  $\geq 2404.2$  mg/kg body weight in adult male albino rats as shown in Table 1.

Table 2 shows the body weight difference of the experimental rats used for the study. From the table a 30.95% increase in the body weight of the control group rats was observed, while 8.39% and 2.86% increases in the body weight of rats administered 200 and 400 mg/kg body weight of STDC extract were observed, respectively.

The antioxidant profile (Table 3 and Fig. 1-6) showed dose-related changes in several biomarkers following treatment. CAT activity increased progressively from  $3.52 \pm 0.10$   $\mu\text{g}$  in the control group to  $3.85 \pm 0.35$   $\mu\text{g}$  at 200 mg/kg and  $5.30 \pm 1.52$   $\mu\text{g}$  at 400 mg/kg, indicating an apparent enhancement of catalase activity with increasing treatment dose, although the common superscript suggests that these differences were not statistically significant. Similarly, SOD activity increased from  $0.30 \pm 0.03$   $\mu\text{mL}$  in the control to  $0.47 \pm 0.13$   $\mu\text{mL}$  and  $0.46 \pm 0.02$   $\mu\text{mL}$  in the 200 and 400 mg/kg groups, respectively. This pattern suggests an improvement in enzymatic antioxidant defence following treatment. MDA, an indicator of lipid peroxidation and oxidative damage, decreased markedly from  $0.48 \pm 0.02$   $\mu\text{mol/mL}$  in the control to  $0.18 \pm 0.13$   $\mu\text{mol/mL}$  at 200 mg/kg, followed by a slight increase to  $0.32 \pm 0.02$   $\mu\text{mol/mL}$  at 400 mg/kg. Thus, the 200 mg/kg group exhibited the lowest MDA concentration, suggesting reduced lipid peroxidation at this dose. However, the observed differences were not statistically significant.

The most pronounced change was observed in GSH, which increased from  $0.712 \pm 0.146$  mg/dL in the control to  $1.360 \pm 0.119$  mg/dL at 200 mg/kg. This increase was

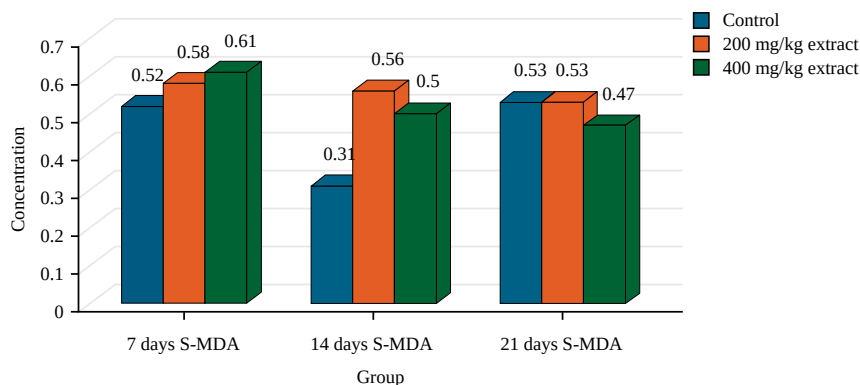


Fig. 1: Concentration of serum GSH in experimental rats administered STDC after 7, 14 and 21 days

Table 1: Acute oral toxicity test ( $LD_{50}$ ) of STDC

| Number of rats | Dose (mg/kg) | Sex  | Mortality |
|----------------|--------------|------|-----------|
| <b>Phase 1</b> |              |      |           |
| 3/3            | 10           | Male | 0/3       |
| 3/3            | 100          | Male | 0/3       |
| 3/3            | 1000         | Male | 0/3       |
| <b>Phase 2</b> |              |      |           |
| 2/2            | 850          | Male | 0/2       |
| 2/2            | 1700         | Male | 0/2       |
| 2/2            | 3400         | Male | ½         |
| 2/2            | 6800         | Male | ½         |

$LD_{50}$ : Lethal dose,  $LD_{50} = \sqrt{a \times b}$  of STDC =  $3400 \times 1700$  mg/kg = 2404.2 mg/kg body weight. Therefore,  $LD_{50}$  of STDC is  $\geq 2404.2$  mg/kg body weight in adult male rat model

statistically significant, suggesting enhanced non-enzymatic antioxidant capacity at 200 mg/kg. At 400 mg/kg, GSH declined to  $0.766 \pm 0.149$  mg/dL, approaching the control value. In contrast, GPX decreased from  $0.061 \pm 0.006$  mg/dL in the control to  $0.035 \pm 0.007$  mg/dL and  $0.032 \pm 0.006$  mg/dL at 200 and 400 mg/kg, respectively. GST also declined from  $0.337 \pm 0.268$  mg/dL in the control to  $0.172 \pm 0.042$  mg/dL and  $0.157 \pm 0.101$  mg/dL in the treatment groups. The findings indicate that treatment with extract particularly enhanced CAT, SOD and GSH responses, while GPX and GST showed downward trends.

This study evaluated the antioxidant and oxidative stress-modulatory effects of a synergistic formulation comprising *Cyperus esculentus* (tiger nut), *Phoenix dactylifera* (date fruit) and *Cocos nucifera* (coconut) extracts (STDC) in male Wistar rat model. The findings demonstrate that the combined extract significantly enhanced endogenous antioxidant defense mechanisms while reducing biomarkers of oxidative damage, suggesting a protective role against reactive oxygen species (ROS)-mediated cellular injury. These effects may be attributed to the rich phytochemical composition of the constituent plants, including polyphenols, flavonoids, tocopherols, carotenoids, phenolic acids and unsaturated fatty acids, which have been widely reported to possess potent antioxidant activities<sup>14</sup>.

**Acute toxicity and safety implications of STDC:** The acute toxicity assessment as shown in Table 1 revealed an oral  $LD_{50}$  of  $\geq 2404.2$  mg/kg body weight, indicating that the synergistic extract possesses relatively low toxicity and can be considered practically safe according to conventional toxicological classifications. Although mild signs of toxicity and partial mortality were observed at extremely high doses (3400-6800 mg/kg), the experimental doses employed in this study (200 and 400 mg/kg) were considerably lower than the toxic threshold. This safety profile supports the potential development of STDC as a nutraceutical or functional food ingredient for long-term consumption.

The observed safety may be related to the natural origin of the constituents and their long history of dietary use. Previous studies have demonstrated that tiger nut, date fruit and coconut possess low toxicity and high nutritional value, making them suitable candidates for preventive nutritional interventions against oxidative stress-related diseases<sup>15</sup>.

**Effect of STDC on body weight:** The treated groups (2 and 3) exhibited lower percentage body weight gains (8.39 and 2.86%) compared with the control group (30.95%) as observed in Table 2. This finding suggests that STDC may influence energy metabolism, nutrient utilization, or lipid metabolism. Tiger nut contains high dietary fiber and resistant starch,

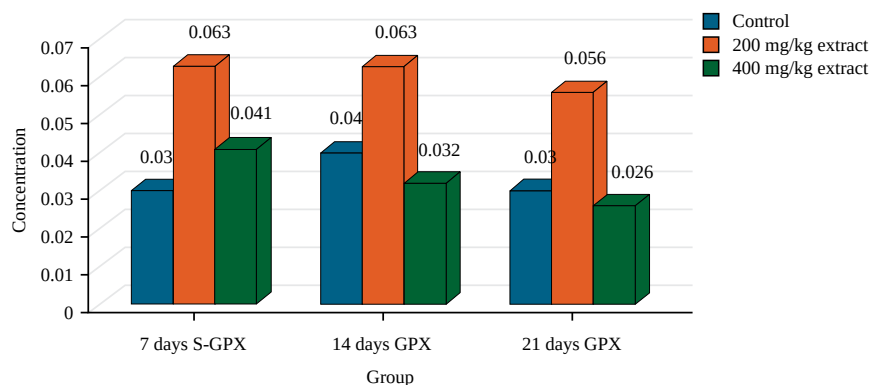


Fig. 2: Concentration of serum GPx in experimental rats administered STDC after 7, 14 and 21 days

Table 2: Percentage body weight difference in experimental rats exposed to a synergistic mixture of *Cyperus esculentus*, *Phoenix dactylifera* and *Cocos nucifera*

| Groups                   | Initial body weight (g) | Final body weight (g) | Body weight difference (%) |
|--------------------------|-------------------------|-----------------------|----------------------------|
| Group 1 (control)        | 69.80±7.50              | 121.00±30.83          | 30.95                      |
| Group 2 (200 mg/kg STDC) | 88.20±5.12              | 121.20±29.20          | 8.39                       |
| Group 3 (400 mg/kg STDC) | 111.80±6.72             | 123.00±11.68          | 2.86                       |

Values are expressed as Mean ± Standard Deviation

which can improve satiety and regulate glucose absorption. Similarly, date fruit polyphenols and coconut medium-chain triglycerides (MCTs) have been associated with enhanced energy expenditure and improved metabolic efficiency. The attenuation of excessive body weight gain may therefore indicate metabolic regulatory effects of the extract. Such effects could be beneficial in obesity-associated oxidative stress, where excess adiposity promotes ROS generation through mitochondrial dysfunction and chronic inflammation. Similar reductions in weight gain have been reported for polyphenol-rich plant extracts capable of improving insulin sensitivity and lipid utilization<sup>16</sup>.

One of the most significant findings of the study was the elevation of serum reduced glutathione (GSH) as revealed in Table 3 and Fig. 1, particularly in the 200 mg/kg treatment group (1.360 mg/dL) compared with the control (0.712 mg/dL) after 7, 14 and 21 days. The GSH is the most abundant intracellular non-enzymatic antioxidant and serves as a critical defense molecule against ROS. It directly scavenges hydroxyl radicals, singlet oxygen and peroxides while acting as a cofactor for glutathione peroxidase (GPx). The elevated GSH concentration observed in the treated animals suggests that STDC enhances cellular redox homeostasis by either stimulating GSH biosynthesis or reducing its depletion during oxidative stress. Polyphenols present in tiger nut and date fruit may activate the Nrf2/ARE signaling pathway, leading to increased expression of genes involved in glutathione synthesis, including glutamate-cysteine ligase and glutathione synthetase. Increased GSH levels imply improved cellular

protection against oxidative damage to lipids, proteins and DNA. This observation is particularly relevant because depletion of GSH is a hallmark of chronic diseases such as diabetes mellitus, neurodegeneration, cardiovascular disorders and cancer<sup>17</sup>.

Although GPx and GST activities showed variable responses following treatment as shown in Table 3 and Fig. 2 and 3, their maintenance within physiological ranges suggests preservation of glutathione-dependent detoxification systems. GPx utilizes GSH to neutralize hydrogen peroxide and lipid hydroperoxides, while GST catalyzes conjugation reactions involved in xenobiotic detoxification<sup>18,19</sup>. The relatively lower GPx activity observed in treated groups may reflect reduced oxidative burden resulting from enhanced primary antioxidant defenses (SOD, CAT and GSH), thereby decreasing the demand for GPx-mediated peroxide detoxification. Similarly, reduced GST activity may indicate diminished generation of toxic electrophilic products requiring glutathione conjugation. Such observations suggest that STDC reduces oxidative stress at its source rather than merely stimulating detoxification pathways. Similar findings have been reported in studies where potent antioxidant-rich diets lowered oxidative challenge and consequently reduced compensatory antioxidant enzyme activation<sup>20</sup>.

Superoxide dismutase represents the first line of enzymatic antioxidant defense by catalyzing the conversion of superoxide radicals ( $O_2O^-$ ) into hydrogen peroxide and molecular oxygen. The study demonstrated higher SOD activities in STDC-treated animals compared with controls as

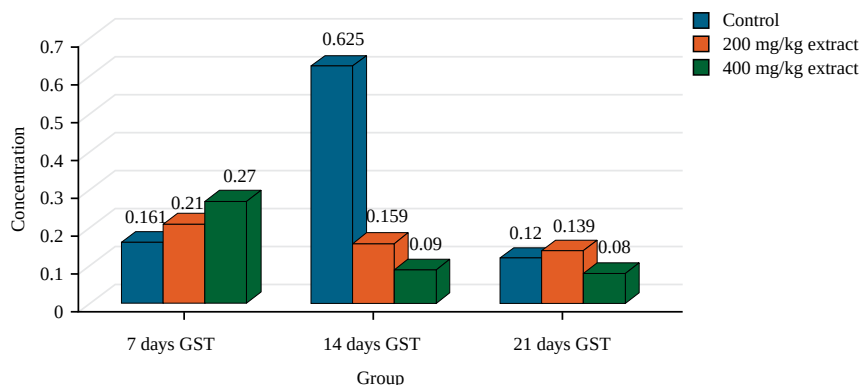


Fig. 3: Concentration of serum GST in experimental rats administered STDC after 7, 14 and 21 days

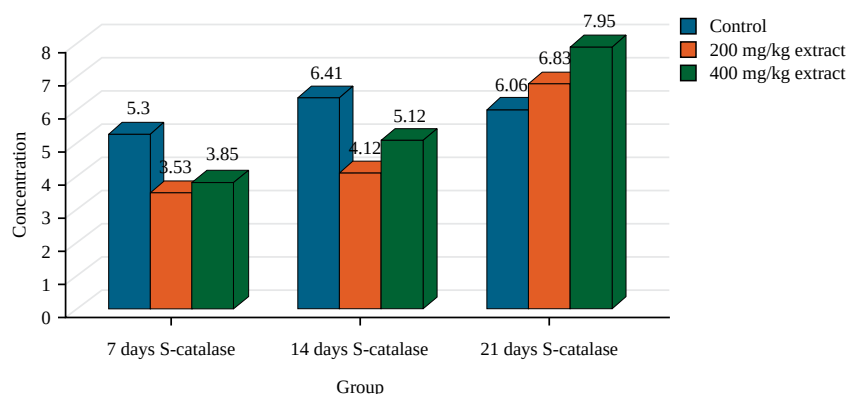


Fig. 4: Concentration of serum Catalase in experimental rats administered STDC after 7, 14 and 21 days

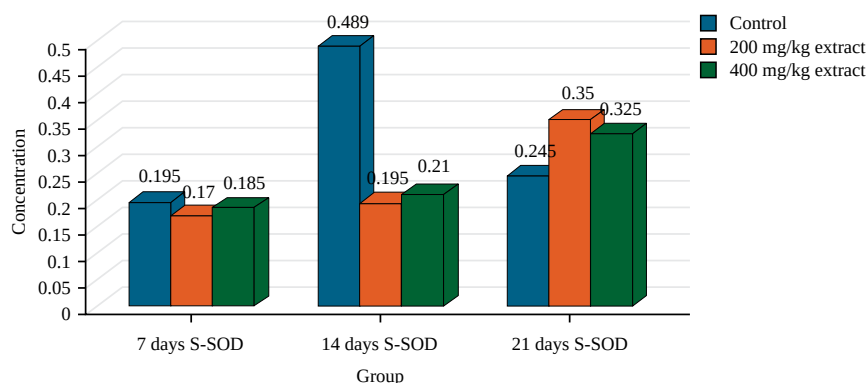


Fig. 5: Concentration of serum SOD in experimental rats administered STDC after 7, 14 and 21 days

revealed in Table 3 and Fig. 4 after 7, 14 and 21 days of treatment, especially during the early phase (7 days) of treatment. The increase in SOD activity suggests enhanced detoxification of superoxide radicals generated during mitochondrial respiration. Bioactive compounds in date fruit, particularly flavonoids and phenolic acids, have been reported to upregulate antioxidant enzyme expression through redox-sensitive transcription factors such as Nrf2 and FOXO pathways<sup>21</sup>. Improved SOD activity reduces oxidative burden within tissues and limits oxidative damage to mitochondrial

membranes. Consequently, enhanced SOD activity contributes to improved cellular function and may delay the progression of oxidative stress-associated diseases including hypertension, atherosclerosis and neurodegenerative disorders<sup>22</sup>.

Catalase activity increased substantially in the treated groups (Table 3 and Fig. 5), with the highest activity observed in rats administered 400 mg/kg STDC (5.30  $\mu$ g) compared with controls (3.52  $\mu$ g). Catalase catalyzes the decomposition of hydrogen peroxide into water and oxygen, preventing the formation of highly reactive hydroxyl radicals through the

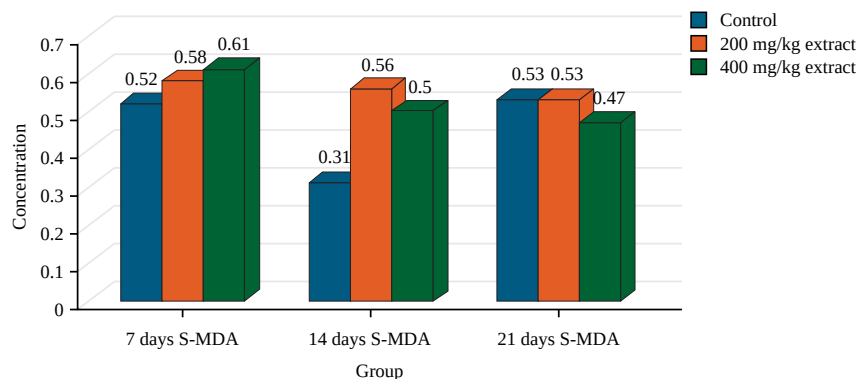


Fig. 6: Concentration of serum MDA in experimental rats administered STDC after 7, 14 and 21 days

Table 3: Effect of the synergistic mixture of tiger nut seeds, dates and coconut on the serum antioxidant/oxidative stress status of the male albino rat model

| Groups              | CAT ( $\mu$ g)    | MDA ( $\mu$ mol/mL) | SOD ( $\mu$ mL)   | GSH (mg/dL)            | GPX (mg/dL)            | GST (mg/dL)         |
|---------------------|-------------------|---------------------|-------------------|------------------------|------------------------|---------------------|
| Group 1(control)    | $3.52 \pm 0.10^a$ | $0.48 \pm 0.02^a$   | $0.30 \pm 0.03^a$ | $0.712 \pm 0.146^a$    | $0.061 \pm 0.006^b$    | $0.337 \pm 0.268^a$ |
| Group 2 (200 mg/kg) | $3.85 \pm 0.35^a$ | $0.18 \pm 0.13^a$   | $0.47 \pm 0.13^a$ | $1.360 \pm 0.119^b$    | $0.035 \pm 0.007^{ac}$ | $0.172 \pm 0.042^a$ |
| Group 3 (400 mg/kg) | $5.30 \pm 1.52^a$ | $0.32 \pm 0.02^a$   | $0.46 \pm 0.02^a$ | $0.766 \pm 0.149^{ac}$ | $0.032 \pm 0.006^a$    | $0.157 \pm 0.101^a$ |

Fenton reaction. The elevation of catalase activity indicates that STDC effectively enhances the second stage of antioxidant defense following SOD-mediated superoxide detoxification. The coordinated increase in both SOD and catalase suggests efficient elimination of ROS and improved maintenance of intracellular redox balance. This finding may be linked to the high vitamin E, tocopherol and phenolic contents of tiger nut and coconut<sup>23,24</sup>. Previous studies have shown that natural antioxidants stimulate catalase gene expression through activation of antioxidant response elements (AREs) and inhibition of oxidative stress-induced signaling pathways<sup>25</sup>. The implication is that STDC may provide protection against hydrogen peroxide-mediated cellular injury, thereby reducing risks associated with chronic inflammatory diseases and aging.

Perhaps the most important finding of this study was the significant reduction in serum malondialdehyde (MDA), a widely recognized biomarker of lipid peroxidation. The 200 mg/kg treatment group showed the lowest MDA concentration ( $0.18 \mu\text{mol/mL}$ ) compared with the control group ( $0.48 \mu\text{mol/mL}$ ) (Table 3, Fig. 6). MDA is generated when ROS attack polyunsaturated fatty acids within cellular membranes. Elevated MDA levels indicate membrane damage, altered membrane fluidity, impaired cellular signaling and initiation of inflammatory cascades<sup>26</sup>. Therefore, the reduction in MDA strongly indicates attenuation of oxidative damage by STDC. The reduction in lipid peroxidation likely results from the synergistic action of: Phenolic compounds from date fruits, Tocopherols and flavonoids from tiger nuts and Polyphenols and medium-chain fatty acids from

coconut. These compounds may directly scavenge free radicals while simultaneously enhancing endogenous antioxidant defenses. Reduced MDA levels imply preservation of membrane integrity, improved cellular viability and decreased risk of oxidative stress-related pathologies. From a clinical perspective, lowering MDA concentrations may contribute to reduced susceptibility to cardiovascular diseases, diabetes complications, hepatic injury, neurodegenerative disorders and accelerated aging processes<sup>26</sup>.

The antioxidant effects observed in this study can be mechanistically explained through activation of the Nrf2-Keap1 antioxidant signalling pathway. Under oxidative conditions, Polyphenols and flavonoids from STDC interact with Keap1, Nrf2 dissociates from Keap1 and translocates to the nucleus, Nrf2 binds antioxidant response elements (ARE), Transcription of antioxidant genes increases, Enhanced synthesis of SOD, CAT, GPx, GST and Glutathione synthesis enzymes.

**Consequently:** STDC phytochemicals→Nrf2 activation→Increased GSH, SOD, CAT→Reduced ROS→Reduced lipid peroxidation (MDA)→Cellular protection. Simultaneously, phenolic compounds may inhibit activation of NF- $\kappa$ B, thereby suppressing oxidative stress-induced inflammation. The dual antioxidant and anti-inflammatory actions provide a mechanistic basis for the observed biochemical changes.

The findings suggest that STDC possesses significant potential applications in: Enhanced antioxidant defenses may protect pancreatic  $\beta$ -cells from ROS-induced apoptosis and improve insulin sensitivity, Reduced lipid peroxidation may

prevent LDL oxidation and endothelial dysfunction, thereby reducing atherosclerotic risk, Improved antioxidant status may protect neurons against oxidative injury implicated in Alzheimer's and Parkinson's diseases, Lower ROS levels and reduced oxidative damage can delay cellular senescence and age-associated tissue degeneration.

The combination of tiger nut, date fruit and coconut could be developed into antioxidant-rich beverages, nutraceutical supplements, or functional dietary formulations.

## CONCLUSION

The study demonstrates that the synergistic combination of *Cyperus esculentus*, *Phoenix dactylifera* and *Cocos nucifera* exerts substantial antioxidant effects in Wistar rats through enhancement of endogenous antioxidant defenses and suppression of lipid peroxidation. The extract significantly elevated GSH, catalase and SOD activities while reducing MDA concentrations, indicating improved redox homeostasis and protection against oxidative stress. Mechanistically, these effects are likely mediated through activation of the Nrf2-dependent antioxidant pathway and attenuation of ROS generation. The favourable safety profile together with the potent antioxidant activity highlights the potential of STDC as a functional nutraceutical for the prevention and management of oxidative stress-associated diseases.

## SIGNIFICANCE STATEMENT

The study demonstrates that a combined extract of tiger nut, date fruit and coconut enhances endogenous antioxidant defenses and reduces lipid peroxidation in Wistar rats. The findings support the potential of this synergistic plant-based combination as a natural source of antioxidant activity and provide a basis for further investigation of its possible nutraceutical applications in oxidative stress-related conditions.

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