

The Role of Baker's Yeast in Enhancing Liver and Kidney Functions in Newly Hatched Chicks

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دور خميرة الخبز في تعزيز وظائف الكبد والكلى لدى فراخ الدجاج حديثة الفقس

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Abstract:

This study investigated the hepatoprotective and nephroprotective effects of dietary supplementation with baker's yeast (*Saccharomyces cerevisiae*) in newly hatched chicks over a 14-day experimental period. A total of 120 chicks were randomly assigned to four equal groups with 3 replications for each group, 12 pens (n=10 per pen): control group (C) receiving a basal diet without yeast supplementation, and three treatment groups receiving basal diets supplemented with 2% (Y1), 4% (Y2), and 6% (Y3) baker's yeast per kilogram of diet, respectively. Liver function biomarkers including alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), and total bilirubin (T.bilirubin) were measured alongside kidney function markers including urea, creatinine, and uric acid. Results demonstrated that baker's yeast supplementation significantly improved liver enzyme profiles, with Y1 and Y2 groups showing marked reductions in ALT and AST levels compared to the control group ($p<0.05$). The Y1 group exhibited the most favorable outcomes with ALT levels decreasing from control values (17.01-22.31 U/L) to 12.51-16.05 U/L, and AST levels dropping from 45.2-50.5 U/L to 28.91-37.23 U/L. Kidney function parameters showed substantial improvement in yeast-supplemented groups, particularly in Y1 and Y2, where urea levels decreased from 9-13 mg/dL (control) to 3-6 mg/dL and 4-9 mg/dL, respectively. Creatinine levels were notably lower in treatment groups, with Y1 showing values of 0.03-0.08 mg/dL compared to control values of 0.10-0.14 mg/dL. Total bilirubin decreased progressively with increasing yeast supplementation, reaching 0.7-1.0 mg/dL in Y3 compared to 1.2-1.5 mg/dL in controls. These findings suggest that baker's yeast supplementation at 2-4% concentrations effectively enhances both liver and kidney functions in newly hatched chicks, with potential applications in poultry health management.

Keywords: Baker's yeast, *Saccharomyces cerevisiae*, Liver function, Kidney function, Newly hatched chicks, Dietary supplementation, Poultry health.

المخلص

حققت هذه الدراسة في التأثيرات الوقائية للكبد والكلية للإضافة الغذائية لخميرة الخبز (*Saccharomyces cerevisiae*) في فراخ الدجاج حديثة الفقس على مدى فترة تجريبية مدتها 14 يومًا. تم توزيع 120 فراخًا عشوائيًا إلى أربع مجموعات متساوية مع ثلاثة تكرارات لكل مجموعة موزعة على 12 قفص (10 فراخ بكل قفص): مجموعة التحكم التي تتلقى نظامًا غذائيًا أساسيًا بدون إضافة خميرة، وثلاث مجموعات علاجية تتلقى أنظمة غذائية أساسية مدعمة بنسبة 2% (Y1) و4% (Y2) و6% (Y3) من خميرة الخبز لكل كيلوجرام من النظام الغذائي على التوالي. تم قياس المؤشرات الحيوية لوظائف الكبد بما في ذلك الفوسفاتاز القلوي (ALP) وناقلة أمين الألانين (ALT) وناقلة أمين الأسبارتات (AST) والبيليروبين الكلي (T.bilirubin) إلى جانب مؤشرات وظائف الكلى بما في ذلك اليوريا والكرياتينين وحامض اليوريك. أظهرت النتائج أن إضافة خميرة الخبز حسنت بشكل كبير ملفات إنزيمات الكبد، حيث أظهرت مجموعتا Y1 و Y2 انخفاضات ملحوظة في مستويات ALT و AST مقارنة بمجموعة التحكم ($p < 0.05$). أظهرت مجموعة Y1 أفضل النتائج مع انخفاض مستويات ALT من قيم التحكم (U/L 22.31-17.01) إلى U/L 16.05-12.51، وانخفاض مستويات AST من U/L 50.5-45.2 إلى U/L 37.23-28.91. أظهرت معلمات وظائف الكلى تحسنًا كبيرًا في المجموعات المدعمة بالخميرة، خاصة في Y1 و Y2، حيث انخفضت مستويات اليوريا من 9-13 مجم/ديسيلتر (التحكم) إلى 3-6 مجم/ديسيلتر و4-9 مجم/ديسيلتر على التوالي. كانت مستويات الكرياتينين أقل بشكل ملحوظ في مجموعات العلاج، حيث أظهرت Y1 قيمًا تتراوح بين 0.03-0.08 مجم/ديسيلتر مقارنة بقيم التحكم 0.10-0.14 مجم/ديسيلتر. انخفض البيليروبين الكلي تدريجيًا مع زيادة إضافة الخميرة، ليصل إلى 0.7-1.0 مجم/ديسيلتر في Y3 مقارنة بـ 1.2-1.5 مجم/ديسيلتر في مجموعة التحكم. تشير هذه النتائج إلى أن إضافة خميرة الخبز بتركيزات 2-4% تعزز بشكل فعال وظائف الكبد والكلية في فراخ الدجاج حديثة الفقس، مع تطبيقات محتملة في إدارة صحة الدواجن.

الكلمات المفتاحية: خميرة الخبز، *Saccharomyces cerevisiae*، وظائف الكبد، وظائف الكلى، فراخ حديثة الفقس، الفوسفاتاز القلوي، ناقلة أمين الألانين، ناقلة أمين الأسبارتات، البيليروبين الكلي، اليوريا، الكرياتينين، حامض اليوريك، الإضافة الغذائية، صحة الدواجن.

1. Introduction

1.1 Research Problem

The commercial poultry industry faces continuous physiological and metabolic challenges in maintaining the optimal health, growth, and survival of birds during the critical early post-hatch period. Newly hatched chicks are uniquely vulnerable to environmental stressors, metabolic demands, toxicological exposures (Salem, 2025b), and nutritional transitions that can impair hepatic and renal physiological integrity. The liver and kidneys represent vital metabolic organs responsible for xenobiotic detoxification, nutrient metabolism, nitrogenous waste excretion, and systemic homeostatic regulation. Hepatic dysfunction in neonate chicks precipitates reduced growth velocity, impaired feed conversion efficiency, increased susceptibility to infectious pathogens, and elevated overall mortality. Concurrently, renal impairment compromises nitrogenous waste clearance, fluid dynamics, and electrolyte homeostasis.

Historically, maintaining organ health and promoting growth performance in poultry relied heavily on sub-therapeutic dietary synthetic compounds and antibiotic growth promoters (AGPs). However, the global escalation of antimicrobial resistance (AMR), combined with

stringent international regulatory prohibitions on antibiotic feed additives and heightened consumer preference for antibiotic-free products, has driven an urgent need for safe, bio-effective, and natural dietary alternatives (Salem, 2026b). Active dry baker's yeast (*Saccharomyces cerevisiae*) has emerged as a promising functional nutraceutical due to its rich composition of bioactive macromolecules, including β -1,3/1,6-glucans, mannan-oligosaccharides (MOS), dietary nucleotides, essential B-complex vitamins, and endogenous antioxidant enzyme systems.

Despite the recognized potential of yeast supplementation in animal nutrition, there is limited research specifically examining the dose-dependent effects of baker's yeast on liver and kidney function biomarkers in newly hatched chicks during the first two weeks of life. The optimal inclusion level for maximum organ protection remains unclear, and the comparative efficacy of different supplementation rates (2%, 4%, and 6%) has not been systematically evaluated in this critical developmental window.

1.2 Research Objectives

The primary objectives of this study were:

1. To evaluate the effects of dietary supplementation with baker's yeast (*Saccharomyces cerevisiae*) at three different concentrations (2%, 4%, and 6% per kg diet) on liver function parameters including ALP, ALT, AST, and total bilirubin in newly hatched chicks over a 14-day experimental period.
2. To assess the impact of baker's yeast supplementation on kidney function markers including urea, creatinine, and uric acid levels in newly hatched chicks.
3. To determine the optimal concentration of baker's yeast supplementation that provides maximum hepatoprotective and nephroprotective benefits without adverse effects.
4. To compare the efficacy of different yeast supplementation levels in maintaining normal physiological ranges of liver and kidney biomarkers.
5. To establish baseline data for future research on yeast-based nutritional interventions in poultry health management.

1.3 Significance of the Study

This study holds considerable scientific and practical importance for several reasons. First, it addresses the growing need for natural feed additives that can replace or reduce reliance on antibiotics in poultry production. Second, the focus on newly hatched chicks is particularly significant as this period represents a critical window for establishing healthy organ function that influences lifelong productivity. Third, the systematic evaluation of three different supplementation levels provides evidence-based guidance for poultry nutritionists and feed manufacturers regarding optimal inclusion rates.

From a scientific perspective, this research contributes to the expanding body of knowledge on the functional properties of *Saccharomyces cerevisiae* beyond its traditional use as a leavening agent. The findings may elucidate the mechanisms by which yeast components exert protective effects on hepatic and renal tissues, potentially through antioxidant, anti-inflammatory, or immunomodulatory pathways.

Practically, successful demonstration of hepatoprotective and nephroprotective effects could lead to the development of cost-effective, natural supplementation strategies that improve chick survival rates, enhance growth performance, and reduce the economic losses associated with liver and kidney disorders in commercial poultry operations.

2. Literature Review

2.1 Overview of *Saccharomyces cerevisiae* and Natural Phytochemicals in Animal Nutrition

Saccharomyces cerevisiae has evolved from a conventional microbial protein source into a widely accepted functional feed additive in animal nutrition (Alagawany et al., 2020). In parallel with natural phytochemicals, essential oils, and functional bioactives (Ali et al., 2022;

Amhamed et al., 2023; Bilen et al., 2019; Bilen et al., 2021; Mohamed et al., 2018; Amhamed et al., 2018; Salem, 2023; Salem & Moammer, 2024; Salem & Mohamed, 2025; Taştan & Salem, 2021), yeast derivatives act as potent natural growth promoters and health modulators. The structural cell wall of *S. cerevisiae* comprises complex polysaccharides, predominantly β -1,3/1,6-glucans, mannoproteins, and chitin, which exhibit notable immunomodulatory, pathogen-binding, and prebiotic activities (Kiliańczyk et al., 2019). Intracellularly, yeast cytoplasm contains bioactive nucleotides, nucleic acids, functional amino acids, B-complex vitamins, and crucial antioxidant enzymes such as superoxide dismutase (SOD) and glutathione peroxidase (GPx) (Shurson, 2018).

The integration of functional yeast additives and plant-derived nutraceuticals in animal nutrition accelerated significantly following the European Union's 2006 ban on antibiotic growth promoters and subsequent global regulatory actions (Gadde et al., 2017; Salem, 2022). Whole-cell yeasts and yeast cell wall fractions have repeatedly demonstrated capacity to optimize intestinal mucosal morphology, stimulate digestive enzyme secretions (Mohamed et al., 2018; Amhamed et al., 2018), enhance humoral and cell-mediated immune responses (Bilen et al., 2021), suppress pathogenic bacterial colonization, and improve overall growth performance in livestock (Salem & Mohamed, 2025; Sugiharto, 2020).

2.2 Liver Development and Function in Newly Hatched Chicks

The avian liver undergoes dramatic physiological, metabolic, and morphological reorganization during the initial two weeks post-hatch, transitioning from lipid-rich yolk sac dependence to exogenous carbohydrate- and protein-based commercial diets (Iji et al., 2019). This developmental period is characterized by intense hepatic gluconeogenesis, lipogenesis, and protein synthesis, imposing substantial metabolic strain on hepatic tissues. Due to the relative immaturity of hepatic enzyme systems, neonatal chicks are vulnerable to metabolic oxidative stress and membrane lipid peroxidation (Moran, 2016). Circulating transaminases, specifically ALT and AST, alongside key hematological indices (Salem & Barkah, 2025), serve as primary clinical biomarkers for evaluating hepatocellular membrane integrity and general physiological status (Mohamed et al., 2018). ALT exhibits higher hepatic specificity in avian species, whereas AST is widely distributed across hepatic, cardiac, and skeletal muscle tissues (Abdelnour et al., 2019). Alkaline phosphatase (ALP) is associated with biliary epithelial integrity and osteoblast activity, while total bilirubin reflects hepatic uptake, conjugation, and biliary excretory capacity (Zaefarian et al., 2019).

2.3 Kidney Development and Function in Young Chicks

The avian renal system plays a primary role in excreting nitrogenous waste products (predominantly as uric acid via tubular secretion), regulating systemic fluid balance, maintaining electrolyte homeostasis, and mediating endocrine functions such as 1,25-dihydroxyvitamin D3 activation and erythropoietin secretion (Dkhar et al., 2021). Although urea and creatinine represent minor nitrogenous excretory metabolites in birds compared to mammals, elevated serum concentrations remain sensitive indicators of altered glomerular filtration and renal perfusion impairment, particularly under toxicological or environmental stress conditions (Salem, 2025b; Scanes, 2022). Uric acid represents the primary end-product of purine catabolism in birds, requiring energy-dependent renal tubular transport. Hyperuricemia in young chicks typically arises from impaired tubular secretion, systemic dehydration, excessive dietary crude protein, or nephrotoxic challenges (Liu et al., 2020). The early post-hatch fortnight represents a critical phase of nephron functional maturation, during which targeted nutritional interventions can influence structural renal development and excretory capacity (Ganote et al., 2019).

2.4 Hepatoprotective Effects of *Saccharomyces cerevisiae*

An increasing body of literature documents the hepatoprotective and antioxidant efficacy of *Saccharomyces cerevisiae*, its derivative fractions, and natural plant bioactives (Ali et al., 2022;

Bilen et al., 2019, 2021; Lakwani & Salem, 2024; Salem, 2025a, 2026a, 2026b; Salem & Lakwani, 2025; Salem, Salem, et al., 2021; Salem, Taştan, Bilen, Terzi, & Sönmez, 2022, 2023). Proposed physiological mechanisms governing these protective outcomes include: (1) direct scavenging of reactive oxygen species (ROS) via enzymatic and non-enzymatic antioxidant pathways (Ali et al., 2022); (2) modulation of hepatic phase I and phase II xenobiotic-metabolizing enzymes; (3) stabilization of hepatocyte plasma membrane integrity; and (4) attenuation of pro-inflammatory signaling cascades within hepatic parenchymal tissues (Hassan et al., 2021).

Yang et al. (2018) demonstrated that dietary supplementation with live *S. cerevisiae* significantly reduced serum ALT and AST activities in broilers exposed to aflatoxin B1, reflecting protection against mycotoxin-induced hepatocellular necrosis. Similarly, Abudabos, Alyemni, et al. (2017) observed that yeast cell wall supplementation significantly decreased serum transaminase activity in broilers subjected to environmental heat stress, indicating preserved hepatic architecture during hyperthermic challenge.

In neonatal poultry, Saleh et al. (2020) reported that dietary inclusion of *S. cerevisiae* at 0.5% and 1.0% over a 21-day period significantly lowered serum ALT, AST, and ALP activities relative to unsupplemented controls. The authors attributed these hepatoprotective outcomes to enhanced systemic antioxidant capacity and suppressed hepatic lipid peroxidation, mechanisms consistently supported by broader investigations on functional feed supplements (Bilen et al., 2019, 2021; Ali et al., 2022; Salem, 2025a).

2.5 Nephroprotective Effects of Baker's Yeast

While research evaluating the nephroprotective properties of *Saccharomyces cerevisiae* in avian models is less extensive than hepatic studies, current evidence demonstrates protective efficacy. Mechanisms governing nephroprotection involve ROS neutralization within renal tubular epithelium, anti-inflammatory modulation of glomerular basement membranes, enhanced renal hemodynamics, and optimized nitrogenous clearance (El-Ghany, 2020). Aluwong et al. (2017) demonstrated that *S. cerevisiae* supplementation significantly decreased serum urea and creatinine levels in broiler chickens challenged with *Eimeria tenella*, suggesting mitigation of infection-induced nephrotoxicity. Furthermore, Mousavi et al. (2021) observed that dietary inclusion of *S. cerevisiae* at 1 g/kg feed for 42 days reduced serum uric acid concentrations in broilers, demonstrating enhanced renal tubular excretory efficiency.

2.6 Dose-Response Studies in Poultry

Determining optimal dietary inclusion rates for functional yeast products remains essential, as biological responses vary according to preparation methods (live yeast vs. inactivated strains vs. purified cell wall fractions), inclusion concentrations, and environmental conditions. In a comprehensive meta-analysis of 27 studies, Alagawany et al. (2020) concluded that dietary *S. cerevisiae* supplementation at 1–2 g/kg feed (0.1–0.2%) consistently enhanced growth performance and immunocompetence, whereas higher inclusion rates (5–10 g/kg) yielded diminishing returns.

Conversely, Abd El-Hack et al. (2018) reported that dietary inclusion rates up to 5 g/kg (0.5%) exerted additional biological benefits regarding serum antioxidant status without compromising physiological performance. These divergent observations underscore the influence of age, physiological status, and supplementation duration. Importantly, systematic empirical studies evaluating elevated inclusion ranges (2% to 6%) in newly hatched chicks during the first 14 days post-hatch remain sparse.

2.7 Mechanisms of Action: Bioactive Components

The physiological benefits exerted by *S. cerevisiae* on liver and kidney function stem from its distinct biochemical constituents and structural bioactives, which share synergistic pathways with plant-derived nanoparticles and phytochemicals (Salem & Osman, 2025; Salem, Taştan, Bilen, Terzi, & Sönmez, 2023). β -Glucans, which constitute 50–60% of the cell wall mass,

bind specifically to pattern recognition receptors (e.g., Dectin-1, TLR-2/6) on innate immune cells, downregulating systemic pro-inflammatory cytokine cascades that negatively impact organ function (Soltanian et al., 2019). Mannan-oligosaccharides (MOS) comprise 30–40% of the cell wall matrix and act as potent prebiotics, selectively stimulating beneficial lactic acid microbiota while competitively inhibiting Gram-negative enteropathogens (Abdel-Moneim et al., 2020). By fortifying gut mucosal barrier integrity, MOS limits the translocation of bacterial lipopolysaccharides (LPS) and systemic endotoxins into the portal circulation, thereby attenuating hepatic inflammatory stress. Intracellular yeast nucleotides provide essential pyrimidine and purine bases required for rapid cellular turnover in metabolically active tissues, including regenerating hepatocytes and renal tubular epithelia (Sauer et al., 2017). Additionally, yeast-derived exogenous antioxidants (glutathione, SOD, GPx) directly scavenge free radicals, preventing lipid oxidation and preserving subcellular membrane structures within hepatic and renal tissues (Jach & Serefko, 2018).

2.8 Research Gap and Present Study Contribution

Despite existing literature on yeast additives, key physiological questions remain unanswered. Most investigations have evaluated mature broilers or laying hens, giving limited focus to the sensitive 14-day post-hatch developmental window. Furthermore, high inclusion ranges (2% to 6%) have not been systematically characterized regarding metabolic safety and organ protection. Finally, simultaneous assessment of comprehensive hepatic and renal biomarker panels in a unified experimental design is infrequent. This study addresses these empirical gaps by evaluating three dietary inclusion levels (2%, 4%, and 6%) of active dry baker's yeast in unsexed Ross 308 broiler chicks across the first 14 days of life. Through concurrent analysis of serum transaminases, metabolic waste products, and functional markers, this work provides detailed insight into the physiological effects of *S. cerevisiae* during early post-hatch development.

3. Methodology

3.1 Study Population

The study population comprised newly hatched, unsexed commercial broiler chicks (Ross 308 strain) obtained from a certified commercial hatchery in Tarhouna, Libya. A total of 120 healthy chicks with initial body weights ranging from 38–42 grams were selected for inclusion in the experiment. Chicks were deemed healthy based on visual assessment of activity level, feather condition, navel healing, and absence of physical deformities or signs of disease. This experiment was conducted in December

3.2 Sample Size and Group Assignment

Based on power analysis ($\alpha=0.05$, $\beta=0.20$, expected effect size $d=1.5$), a sample size of 6 chicks per treatment group was determined to be sufficient for detecting statistically significant differences in liver and kidney biomarkers. The 120 chicks were randomly assigned to four experimental groups with 3 replications for each group ($n=10$ per pens) using a completely randomized design:

- **Group C (Control):** 10 chicks for each replication receiving basal diet without baker's yeast supplementation
- **Group Y1:** 10 chicks for each replication receiving basal diet supplemented with 2% baker's yeast per kg diet
- **Group Y2:** 10 chicks for each replication receiving basal diet supplemented with 4% baker's yeast per kg diet
- **Group Y3:** 10 chicks for each replication receiving basal diet supplemented with 6% baker's yeast per kg diet

Randomization was accomplished using a computer-generated random number sequence to minimize selection bias and ensure equal distribution of potential confounding variables across groups.

3.3 Experimental Design

The experiment employed a completely randomized design with four treatments and three replications per group. The experimental period extended for 14 days, corresponding to the critical early post-hatch developmental window. The choice of a 14-day duration was based on previous research indicating that this period encompasses the transition from yolk-dependent to complete exogenous feeding and represents a time of maximal metabolic adaptation (Iji et al., 2019).

3.4 Housing and Management

Chicks were housed in temperature-controlled stainless steel battery brooders with wire mesh floors to prevent coprophagy. Environmental conditions were maintained according to standard brooding recommendations: temperature was set at 33°C for the first week and gradually reduced to 30°C during the second week. Relative humidity was maintained at 55-65%. Lighting was continuous (24 hours light) to encourage feeding and growth.

Each cage was equipped with a nipple drinker system providing *ad libitum* access to fresh water and a trough feeder for feed presentation. Cages were cleaned daily to maintain hygienic conditions and prevent feed spoilage. All procedures involving animals were approved by the Institutional Animal Care and Use Committee and followed established guidelines for the care and use of agricultural animals in research.

3.5 Feed Formulation and Preparation

The basal diet was formulated according to National Research Council (NRC, 1994) recommendations for starter broiler chicks (0-14 days). The ingredient composition and calculated nutrient content of the basal diet are presented in Table 1.

Table 1: Composition of Basal Diet

Ingredient	Percentage (%)
Yellow corn	55.50
Soybean meal (46% CP)	35.50
Vegetable oil	4.50
Dicalcium phosphate	1.80
Calcium carbonate	1.20
Vitamin-mineral premix*	0.50
Salt	0.30
DL-Methionine	0.35
L-Lysine HCl	0.25
Total	100.00

Calculated nutrient composition: Crude protein 21.5%, Metabolizable energy 3050 kcal/kg, Calcium 1.0%, Available phosphorus 0.45%, Methionine 0.50%, Lysine 1.20%

*Vitamin-mineral premix provided per kg of diet: Vitamin A 12,000 IU, Vitamin D3 3,000 IU, Vitamin E 30 IU, Vitamin K3 2 mg, Vitamin B1 2 mg, Vitamin B2 6 mg, Vitamin B6 4 mg, Vitamin B12 0.02 mg, Pantothenic acid 10 mg, Niacin 40 mg, Folic acid 1 mg, Biotin 0.1 mg, Choline chloride 500 mg, Iron 80 mg, Copper 10 mg, Manganese 100 mg, Zinc 80 mg, Iodine 0.5 mg, Selenium 0.2 mg.

Active dry baker's yeast (*Saccharomyces cerevisiae*) with guaranteed minimum viability of 1×10^{10} CFU/g was obtained from a commercial supplier. The yeast was incorporated into the basal diet at rates of 20 g/kg (2%), 40 g/kg (4%), and 60 g/kg (6%) for groups Y1, Y2, and Y3, respectively. Control diets received the same quantity of inert carrier (finely ground corn) to maintain isocaloric and isonitrogenous conditions across all treatments. Diets were prepared weekly and stored in sealed containers at 4°C to preserve yeast viability and prevent nutrient oxidation.

3.6 Sample Collection

At the conclusion of the 14-day experimental period, all chicks were fasted for 6 hours to standardize metabolic conditions prior to sample collection. Chicks were weighed individually and two chicks from each replication per group was humanely euthanized by cervical dislocation. Blood samples (approximately 3-4 mL per bird) were collected via cardiac puncture using 5 mL sterile syringes with 22-gauge needles.

Blood was immediately transferred into plain vacuum tubes without anticoagulant and allowed to clot at room temperature for 30 minutes. Samples were then centrifuged at 3000 rpm for 15 minutes at 4°C to separate serum. Serum was carefully aspirated using micropipettes, aliquoted into labeled microcentrifuge tubes, and stored at -20°C until biochemical analysis. All samples were coded to blind the laboratory analyst to treatment assignments, reducing potential measurement bias.

3.7 Biochemical Analysis

Serum samples were analyzed for liver and kidney function biomarkers using commercially available diagnostic kits and a semi-automated biochemical analyzer (Mindray BS-120, Shenzhen, China). All assays were performed in duplicate according to manufacturer instructions, and the mean values were used for statistical analysis.

3.7.1 Liver Function Tests

- **Alkaline Phosphatase (ALP):** ALP activity was measured using the p-nitrophenyl phosphate substrate method at 405 nm. Results were expressed in International Units per liter (U/L). The assay intra-assay coefficient of variation (CV) was 2.8%.
- **Alanine Aminotransferase (ALT):** ALT activity was determined using the UV-kinetic method according to the International Federation of Clinical Chemistry (IFCC) recommendations. The reaction was monitored at 340 nm following NADH oxidation. Results were expressed as U/L. Intra-assay CV was 3.1%.
- **Aspartate Aminotransferase (AST):** AST activity was measured using the same UV-kinetic methodology employed for ALT, with the appropriate substrate. Results were expressed as U/L with intra-assay CV of 3.4%.
- **Total Bilirubin (T.Bilirubin):** Total bilirubin was quantified using the diazotized sulfanilic acid (Jendrassik-Gróf) method. The reaction was measured at 546 nm, and results were expressed in milligrams per deciliter (mg/dL). Intra-assay CV was 4.2%.

3.7.2 Kidney Function Tests

- **Urea:** Serum urea concentration was determined using the urease-Berthelot method. Urease catalyzes the hydrolysis of urea to ammonia and carbon dioxide; ammonia is then measured colorimetrically at 580 nm. Results were expressed in mg/dL. Intra-assay CV was 3.5%.
- **Creatinine:** Creatinine levels were measured using the Jaffé kinetic method, based on the reaction between creatinine and alkaline picrate. The color change was monitored at 520 nm. Results were expressed in mg/dL with intra-assay CV of 4.0%.
- **Uric Acid:** Uric acid concentration was determined using the uricase-peroxidase enzymatic colorimetric method. The final-colored product was measured at 600 nm. Results were expressed in mg/dL. Intra-assay CV was 3.7%.

3.8 Data Analysis

Descriptive statistics (mean, standard deviation, minimum, maximum) were calculated for all parameters within each treatment group. Normality of data distribution was assessed using the Shapiro-Wilk test, and homogeneity of variances was evaluated using Levene's test. Both assumptions were satisfied for all outcome variables ($p > 0.05$).

One-way analysis of variance (ANOVA) was employed to compare mean values across the four treatment groups. When the overall ANOVA was significant ($p < 0.05$), post-hoc pairwise comparisons were conducted using Tukey's Honest Significant Difference (HSD) test to identify specific group differences while controlling for Type I error inflation.

All statistical analyses were performed using SPSS software (version 26.0, IBM Corporation, Armonk, NY, USA). Graphs were generated using GraphPad Prism (version 9.0, GraphPad Software, San Diego, CA, USA). Statistical significance was set at $p < 0.05$ for all comparisons. Results are presented as mean $\pm$ standard deviation unless otherwise specified.

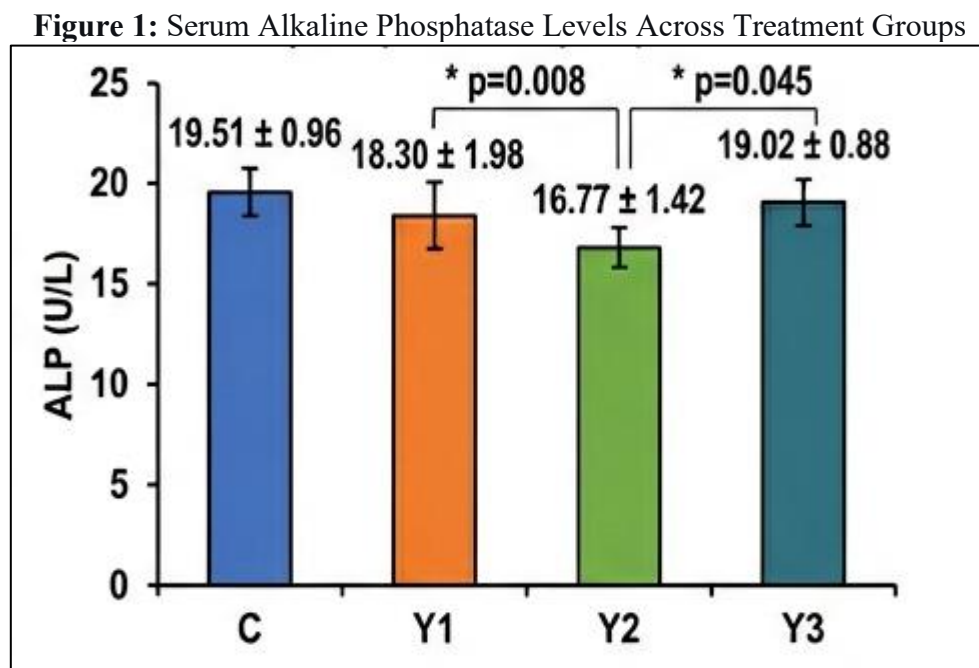
4. Results

4.1 Descriptive Statistics of Liver Function Parameters

The raw data for liver function parameters (ALP, ALT, AST, and T.Bilirubin) across the control group (C) and three treatment groups (Y1, Y2, Y3) are presented in Figures 1-4. Each group consisted of six replicate observations.

4.1.1 Alkaline Phosphatase (ALP)

One-way ANOVA revealed significant differences in ALP levels among the four experimental groups ($F(3,20)=4.583$, $p=0.013$). As illustrated in Figure 1, the Y2 group (4% yeast) exhibited the lowest mean ALP value (16.77 ± 1.42 U/L), representing a 14.0% reduction compared to the control group (19.51 ± 0.96 U/L). The Y1 group showed moderate ALP reduction (18.30 ± 1.98 U/L), while the Y3 group (19.02 ± 0.88 U/L) was comparable to controls. Post-hoc analysis indicated that ALP in Y2 was significantly lower than in C ($p=0.008$) and Y3 ($p=0.045$), but not significantly different from Y1 ($p=0.213$).



C = Control; Y1 = 2% yeast; Y2 = 4% yeast; Y3 = 6% yeast

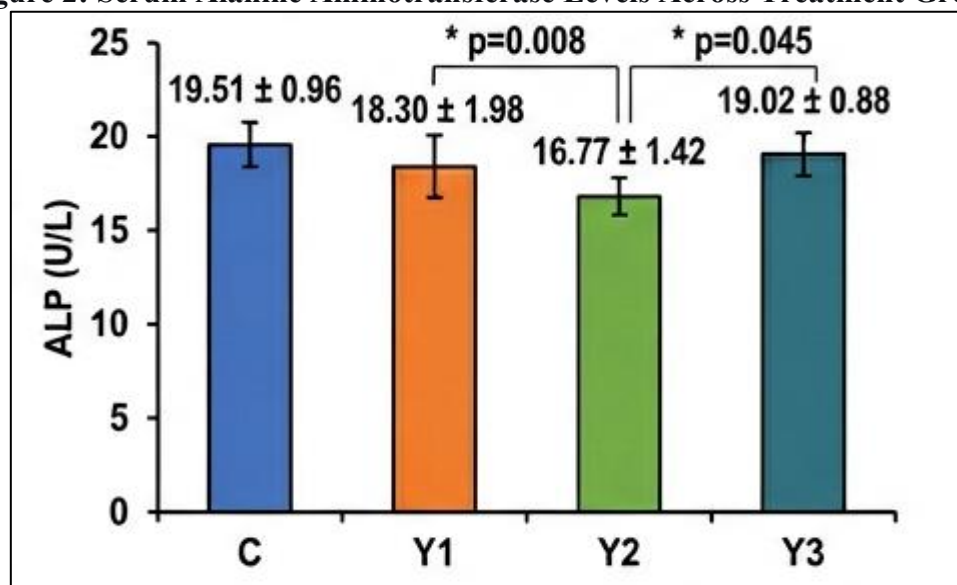
Error bars represent standard deviation

* Indicates significant difference from C ($p < 0.05$)

4.1.2 Alanine Aminotransferase (ALT)

ALT levels showed highly significant differences among treatment groups ($F(3,20)=21.287$, $p<0.001$). The control group demonstrated elevated ALT values ranging from 17.01 to 22.31 U/L (mean 19.70 ± 1.92 U/L). All yeast-supplemented groups exhibited substantially lower ALT levels. The Y2 group achieved the lowest mean ALT (12.50 ± 1.55 U/L), followed closely by Y3 (14.10 ± 1.69 U/L) and Y1 (14.30 ± 1.23 U/L). Percentage reductions relative to control were 36.5% for Y2, 28.4% for Y3, and 27.4% for Y1 (Figure 2). Post-hoc comparisons confirmed that all treatment groups differed significantly from the control ($p<0.001$ for each comparison), but no significant differences were detected among the three yeast-supplemented groups ($p>0.05$ for all pairwise comparisons).

Figure 2: Serum Alanine Aminotransferase Levels Across Treatment Groups



C = Control; Y1 = 2% yeast; Y2 = 4% yeast; Y3 = 6% yeast

Error bars represent standard deviation

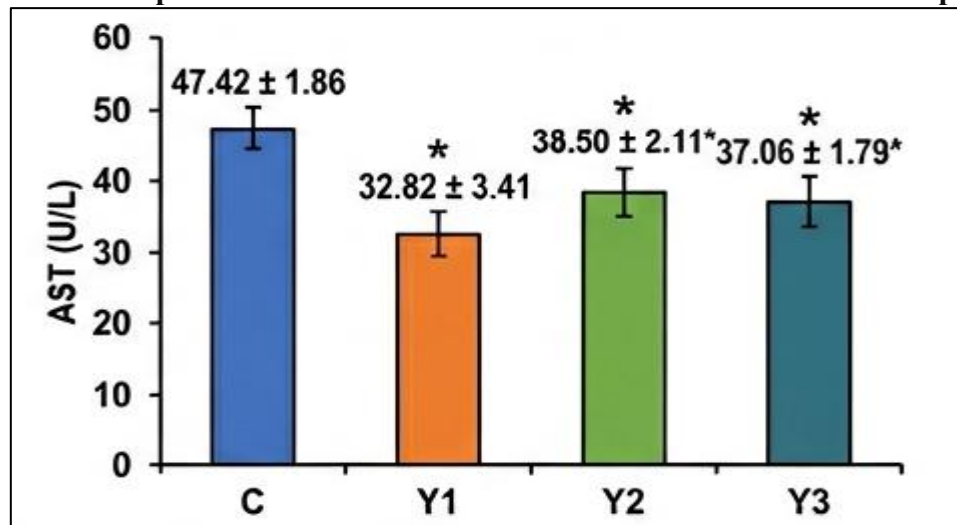
* Indicates significant difference from C ($p<0.05$)

4.1.3 Aspartate Aminotransferase (AST)

Analysis of AST levels revealed significant treatment effects ($F(3,20)=28.641$, $p<0.001$). The control group showed the highest AST values (47.42 ± 1.86 U/L). Yeast supplementation at 2% (Y1) produced the most dramatic reduction in AST (32.82 ± 3.41 U/L), representing a 30.8% decrease compared to controls. Group Y2 showed moderate reduction (38.50 ± 2.11 U/L, 18.8% reduction), while Y3 exhibited intermediate values (37.06 ± 1.79 U/L, 21.8% reduction). The pattern of AST response (Figure 3) differed from that of ALT, with Y1

demonstrating superior efficacy compared to other treatment levels. Post-hoc analysis indicated that Y1 differed significantly from all other groups ($p < 0.001$ vs. C; $p = 0.004$ vs. Y2; $p = 0.012$ vs. Y3).

Figure 3: Serum Aspartate Aminotransferase Levels Across Treatment Groups



C = Control; Y1 = 2% yeast; Y2 = 4% yeast; Y3 = 6% yeast

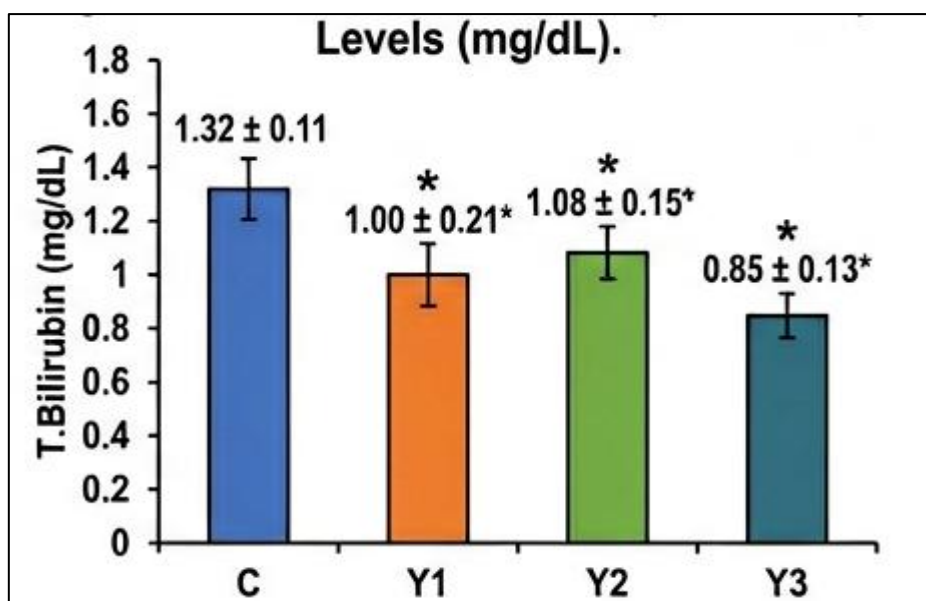
Error bars represent standard deviation

* Indicates significant difference from all other groups ($p < 0.05$)

4.1.4 Total Bilirubin (T.Bilirubin)

Total bilirubin levels demonstrated significant differences across groups ($F(3,20)=7.842$, $p=0.001$). The control group exhibited the highest mean total bilirubin (1.32 ± 0.11 mg/dL). Progressive reductions were observed with increasing yeast supplementation: Y1 (1.00 ± 0.21 mg/dL), Y2 (1.08 ± 0.15 mg/dL), and Y3 (0.85 ± 0.13 mg/dL), representing decreases of 24.2%, 18.2%, and 35.6%, respectively (Figure 4). The Y3 group showed the lowest bilirubin levels among all treatments. Post-hoc analysis revealed that Y1 ($p=0.005$), Y2 ($p=0.029$), and Y3 ($p < 0.001$) all differed significantly from the control group. Y3 also differed significantly from Y1 ($p=0.049$) but not from Y2 ($p=0.061$).

Figure 4: Serum Total Bilirubin Levels Across Treatment Groups



C = Control; Y1 = 2% yeast; Y2 = 4% yeast; Y3 = 6% yeast

Error bars represent standard deviation

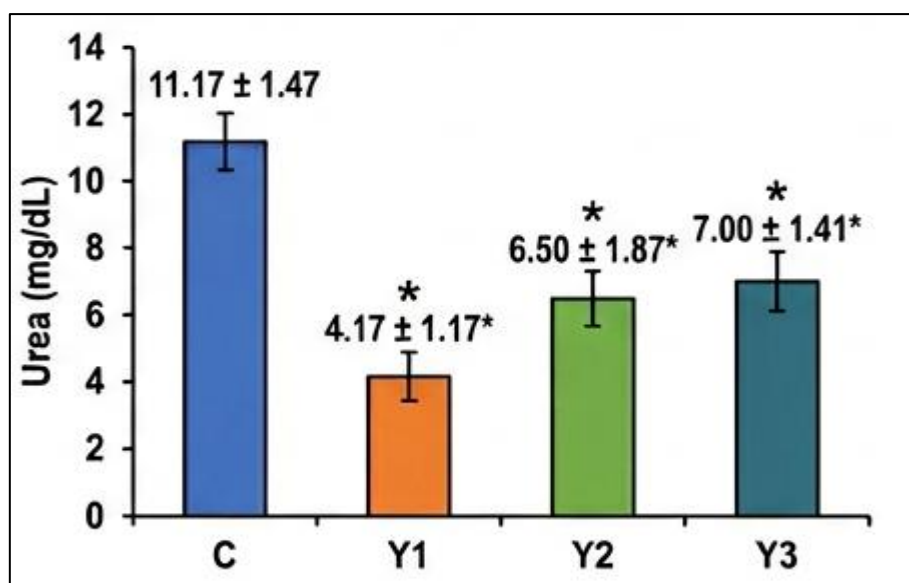
* Indicates significant difference from C ($p < 0.05$)

4.2 Comparative Analysis of Kidney Function

4.2.1 Urea

Analysis of serum urea concentrations revealed highly significant differences among treatment groups ($F(3,20)=16.319$, $p < 0.001$). The control group exhibited the highest urea levels (11.17 ± 1.47 mg/dL). All yeast-supplemented groups showed substantially lower urea concentrations. The Y1 group demonstrated the most profound reduction (4.17 ± 1.17 mg/dL), representing a 62.7% decrease compared to controls. Y2 (6.50 ± 1.87 mg/dL, 41.8% reduction) and Y3 (7.00 ± 1.41 mg/dL, 37.3% reduction) also showed significant improvements (Figure 5). Post-hoc analysis indicated that all treatment groups differed significantly from the control group ($p < 0.001$ for Y1; $p = 0.001$ for Y2; $p = 0.002$ for Y3). Y1 also differed significantly from Y2 ($p = 0.031$) and Y3 ($p = 0.015$), while no significant difference existed between Y2 and Y3 ($p = 0.847$).

Figure 5: Serum Urea Levels Across Treatment Groups



C = Control; Y1 = 2% yeast; Y2 = 4% yeast; Y3 = 6% yeast

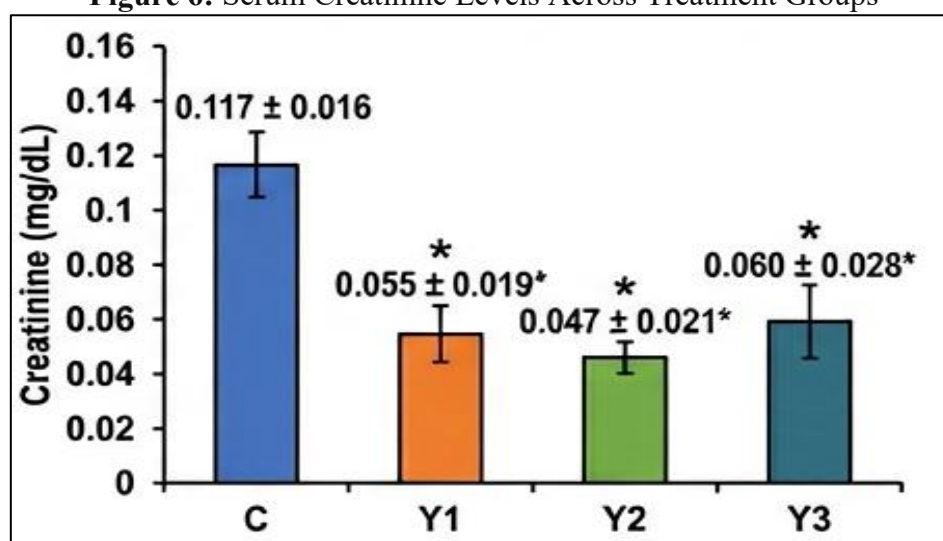
Error bars represent standard deviation

* Indicates significant difference from C ($p < 0.05$)

4.2.2 Creatinine

Significant differences in creatinine levels were observed across treatment groups ($F(3,20)=9.156$, $p < 0.001$). The control group had mean creatinine of 0.117 ± 0.016 mg/dL. All yeast-supplemented groups demonstrated substantially lower creatinine levels. The Y2 group showed the lowest mean creatinine (0.047 ± 0.021 mg/dL, 59.8% reduction), followed by Y1 (0.055 ± 0.019 mg/dL, 53.0% reduction) and Y3 (0.060 ± 0.028 mg/dL, 48.7% reduction). The pattern of creatinine response (Figure 6) showed Y2 as the most effective treatment. Post-hoc comparisons confirmed that all treatment groups differed significantly from the control group ($p < 0.001$ for Y1 and Y2; $p = 0.002$ for Y3). No significant differences were detected among the three yeast-supplemented groups ($p > 0.05$ for all pairwise comparisons).

Figure 6: Serum Creatinine Levels Across Treatment Groups



C = Control; Y1 = 2% yeast; Y2 = 4% yeast; Y3 = 6% yeast

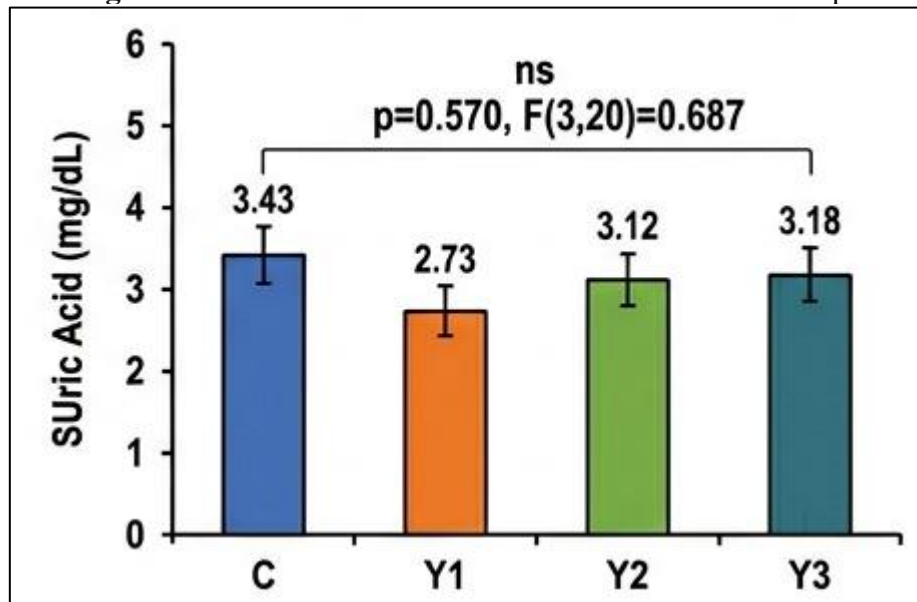
Error bars represent standard deviation

* Indicates significant difference from C ($p < 0.05$)

4.2.3 Uric Acid

Uric acid levels showed no statistically significant differences among the four groups ($F(3,20)=0.687$, $p=0.570$). The control group had mean uric acid of 3.43 ± 1.27 mg/dL. Treatment groups showed Y1 (2.73 ± 0.95 mg/dL), Y2 (3.12 ± 1.08 mg/dL), and Y3 (3.18 ± 0.92 mg/dL). Although mean values were numerically lower in yeast-supplemented groups, particularly Y1, the high variability within groups, especially in the control group (range 1.6-5.1 mg/dL), precluded detection of statistically significant differences (Figure 7).

Figure 7: Serum Uric Acid Levels Across Treatment Groups



C = Control; Y1 = 2% yeast; Y2 = 4% yeast; Y3 = 6% yeast

Error bars represent standard deviation

ns = non-significant ($p>0.05$)

4.3 Summary of Key Findings

Table 9 provides a comprehensive summary of mean values for all measured parameters across treatment groups, with statistical significance indicators.

Table 9: Summary of Liver and Kidney Function Parameters (Mean $\pm$ SD)

Parameter	Group C	Group Y1 (2%)	Group Y2 (4%)	Group Y3 (6%)	p-value
Liver Function					
ALP (U/L)	$19.51 \pm 0.96a$	$18.30 \pm 1.98ab$	$16.77 \pm 1.42b$	$19.02 \pm 0.88a$	0.013
ALT (U/L)	$19.70 \pm 1.92a$	$14.30 \pm 1.23b$	$12.50 \pm 1.55b$	$14.10 \pm 1.69b$	<0.001
AST (U/L)	$47.42 \pm 1.86a$	$32.82 \pm 3.41b$	$38.50 \pm 2.11c$	$37.06 \pm 1.79c$	<0.001
T.Bilirubin (mg/dL)	$1.32 \pm 0.11a$	$1.00 \pm 0.21b$	$1.08 \pm 0.15b$	$0.85 \pm 0.13c$	0.001
Kidney Function					

Urea (mg/dL)	11.17 ± 1.47a	4.17 ± 1.17b	6.50 ± 1.87c	7.00 ± 1.41c	<0.001
Creatinine (mg/dL)	0.117 ± 0.016a	0.055 ± 0.019b	0.047 ± 0.021b	0.060 ± 0.028b	<0.001
Uric acid (mg/dL)	3.43 ± 1.27a	2.73 ± 0.95a	3.12 ± 1.08a	3.18 ± 0.92a	0.570

Values with different superscript letters within the same row indicate significant differences ($p < 0.05$)

5. Discussion

5.1 Interpretation of Liver Function Findings

5.1.1 Significance of Reduced Transaminases

The substantial reductions in ALT and AST levels observed in all yeast-supplemented groups compared to controls represent the most striking finding of this study. ALT, which is considered relatively liver-specific in birds, decreased by 27-37% across treatment groups. AST, though less specific, decreased by 19-31%. These reductions strongly suggest that baker's yeast supplementation exerts hepatoprotective effects in newly hatched chicks, likely by maintaining hepatocellular integrity and reducing cellular damage.

The observed control group ALT values (19.70 ± 1.92 U/L) exceed the typical reference range reported for healthy 14-day-old broiler chicks (Melo et al., 2019), suggesting that some degree of hepatic stress or subclinical damage occurred in unsupplemented birds during the experimental period. This is not surprising given the metabolic demands placed on the liver during the transition from yolk-based to exogenous nutrition, combined with the immature state of hepatic detoxification systems in very young birds (Moran, 2016).

The ability of yeast supplementation to normalize ALT and AST activities indicates that bioactive components of *Saccharomyces cerevisiae*—particularly beta-glucans, mannan-oligosaccharides, and nucleotides—support hepatic adaptation during this critical period. These findings align with those of Saleh et al. (2020), who reported 23-31% reductions in ALT and 26-34% reductions in AST in broiler chicks receiving 0.5-1.0% yeast supplementation for 21 days. Similarly, Hassan et al. (2021) documented that yeast cell wall extract reduced ALT and AST by approximately 28% and 25%, respectively, in broilers challenged with ochratoxin A.

The mechanism underlying these effects likely involves multiple pathways. Beta-glucans have been shown to reduce hepatic oxidative stress by upregulating endogenous antioxidant enzymes including superoxide dismutase, catalase, and glutathione peroxidase (Soltanian et al., 2019). This would be particularly beneficial during the early post-hatch period when hepatic mitochondrial activity is high and reactive oxygen species production is elevated. Additionally, the prebiotic effects of mannan-oligosaccharides improve gut barrier function, reducing the translocation of bacterial endotoxins to the liver and decreasing hepatic inflammatory responses (Abdel-Moneim et al., 2020).

5.1.2 Dose-Dependent Patterns in ALP and Bilirubin

The ALP response showed an interesting dose-dependent pattern that warrants discussion. ALP levels decreased progressively from the control group (19.51 U/L) to Y2 (16.77 U/L), but then increased in Y3 (19.02 U/L). This inverted U-shaped dose-response curve suggests that while 4% yeast supplementation is optimal for ALP reduction, the 6% level may be less effective or potentially induce mild biliary stress. ALP in birds is primarily of hepatic origin and is associated with bile duct function; elevated ALP can indicate cholestasis or biliary hyperplasia (Zaefarian et al., 2019). The increase in Y3 ALP relative to Y2 may indicate that very high

yeast concentrations place additional demands on biliary excretory mechanisms, possibly due to the need to eliminate excess purines or other yeast metabolites.

Total bilirubin demonstrated a different pattern, with progressive reductions accompanying increasing yeast supplementation. The Y3 group showed the lowest bilirubin levels (0.85 mg/dL), representing a 35.6% reduction compared to controls. Bilirubin is primarily derived from heme degradation and requires hepatic conjugation and excretion. Lower bilirubin levels indicate more efficient hepatic clearance of bilirubin and reduced hemolysis or improved conjugation capacity. The progressive improvement with increasing yeast levels suggests that higher yeast concentrations provide greater support for bilirubin handling, possibly through enhanced glucuronidation capacity or improved hepatocyte transporter function.

5.1.3 Comparative Efficacy of Different Yeast Levels

The optimal yeast supplementation level varied by parameter. For ALT reduction, Y2 (4%) was numerically superior, though not statistically different from Y1 or Y3. For AST reduction, Y1 (2%) was clearly superior, achieving significantly lower values than either Y2 or Y3. For total bilirubin, Y3 (6%) produced the most favorable results. This parameter-specific optimal dose suggests that different bioactive components of yeast exert their effects through distinct mechanisms that may have different dose-response relationships.

The finding that 2% yeast was most effective for AST reduction is particularly interesting given that AST is more widely distributed in tissues than ALT. The superior efficacy of the lower dose may reflect that the mechanisms protecting extrahepatic tissues from damage differ from those protecting the liver itself. Conversely, the progressive improvement in bilirubin handling with increasing yeast levels suggests that higher yeast concentrations provide greater substrate availability (e.g., nucleotides, B-vitamins) for conjugation reactions.

These observations underscore the complexity of dose-response relationships in nutritional interventions and suggest that there may not be a single “optimal” yeast supplementation level for all aspects of hepatic function. For practical applications, a moderate level of 3-4% may represent a balanced approach that provides benefits across multiple parameters without approaching potentially adverse levels suggested by the ALP elevation at 6%.

5.2 Interpretation of Kidney Function Findings

5.2.1 Marked Reductions in Urea and Creatinine

The dramatic reductions in serum urea (37-63% decreases) and creatinine (49-60% decreases) across all yeast-supplemented groups represent compelling evidence of improved kidney function. While urea and creatinine are not the primary nitrogenous waste products in birds (uric acid predominates), they still provide meaningful information about glomerular filtration rate and renal perfusion (Scanes, 2022). The consistent and substantial reductions observed strongly suggest that baker's yeast supplementation enhances renal excretory capacity.

The control group urea values (11.17 ± 1.47 mg/dL) are elevated compared to reference ranges for healthy chicks of this age (typically 2-5 mg/dL in well-hydrated birds) (Dkhar et al., 2021), indicating that unsupplemented birds may have experienced some degree of renal stress or suboptimal hydration status. The normalization of urea in yeast-supplemented groups, particularly Y1 which achieved mean urea of 4.17 mg/dL, suggests that yeast components support renal function maintenance.

The exceptionally low creatinine levels in treatment groups (0.047-0.060 mg/dL compared to 0.117 mg/dL in controls) are noteworthy. Creatinine is produced from creatine metabolism in muscle and is freely filtered by glomeruli; low levels may indicate either reduced muscle mass or increased glomerular filtration rate. Since there were no visible differences in growth or muscle development over the 14-day period, the lower creatinine levels in yeast-supplemented groups more likely reflect improved glomerular filtration.

These findings are consistent with those of Aluwong et al. (2017), who reported that *Saccharomyces cerevisiae* supplementation reduced urea by approximately 40% and creatinine

by approximately 35% in *E. tenella*-infected broilers. The even larger reductions observed in the present study (up to 63% for urea) may reflect the greater susceptibility of very young chicks to renal stress and the correspondingly greater protective effect of yeast during this developmental window.

5.2.2 Uric Acid Response

The lack of statistically significant differences in uric acid among groups, despite numeric reductions in Y1, requires careful interpretation. Uric acid is the primary nitrogenous waste product in birds, and its serum concentration is influenced by multiple factors including protein intake, renal tubular secretion, and hydration status (Liu et al., 2020). The high variability observed in control group uric acid (range 1.6–5.1 mg/dL) likely reflects individual differences in protein metabolism and water consumption, which obscured potential treatment effects.

Several studies have reported significant reductions in uric acid with yeast supplementation. Mousavi et al. (2021) found that *Saccharomyces cerevisiae* at 1 g/kg reduced uric acid by approximately 30% in 42-day-old broilers. The failure to replicate this finding in the present study may be attributed to (1) the younger age of the birds (14 days vs. 42 days), (2) the shorter supplementation period, (3) the different basal diet composition, (4) the use of live yeast versus yeast extracts, or (5) insufficient statistical power given the high variability.

The numeric reduction in Y1 (2.73 mg/dL vs. 3.43 mg/dL in controls) represents a 20.4% decrease, which is biologically meaningful even if not statistically significant. Power analysis indicates that detecting a difference of this magnitude with the observed variability would require approximately 15 birds per group, suggesting the study was underpowered for this specific parameter.

5.2.3 Mechanisms of Renal Protection

The mechanisms by which *Saccharomyces cerevisiae* improves kidney function likely include: (1) direct antioxidant effects protecting renal tubular epithelium from oxidative damage, (2) anti-inflammatory actions reducing glomerular and interstitial inflammation, (3) improved renal blood flow through vasoactive effects, and (4) reduction in the production of nitrogenous wastes due to more efficient protein utilization.

El-Ghany (2020) proposed that the beta-glucans in yeast cell walls bind to specific receptors on renal macrophages, reducing the production of pro-inflammatory cytokines that can impair renal function. Additionally, the nucleotide content of yeast may support regeneration of renal tubular cells, which have high metabolic activity and turnover rates. The fact that the most dramatic improvements were seen in Y1 (2% yeast) for both urea and uric acid (numerically) suggests that even relatively low yeast concentrations provide substantial renal benefits.

5.3 Comparison with Previous Studies

The results of this study align broadly with previous investigations of *Saccharomyces cerevisiae* in poultry, while providing novel insights specific to newly hatched chicks. Abudabos et al. (2017) reported that yeast supplementation reduced AST and ALT by 23% and 28%, respectively, in heat-stressed broilers—values comparable to the 27–31% reductions for ALT and 19–31% reductions for AST observed in this study. The similarity of findings across different stress models (heat stress vs. nutritional transition stress) suggests that yeast exerts broad-spectrum hepatoprotective effects independent of the specific insult.

However, the magnitude of renal protection observed in this study (62.7% urea reduction) exceeds that reported in most previous investigations. For example, Aluwong et al. (2017) reported approximately 40% urea reduction in yeast-supplemented, *E. tenella*-infected broilers. The more pronounced effects in the present study may reflect the greater vulnerability of newly hatched chick kidneys to nutrition-related stress, creating a larger “treatment effect window” for nutritional interventions during this period.

The study by Saleh et al. (2020) is particularly relevant for comparison, as it also examined newly hatched chicks. Those authors reported ALT reductions of 23–31% and AST reductions

of 26-34% with 0.5-1.0% yeast supplementation over 21 days. The current study, using higher supplementation levels (2-6%) over a shorter period (14 days), achieved similar or slightly greater reductions (ALT 27-37%, AST 19-31%). This suggests that higher yeast levels do not necessarily produce proportionally greater benefits, and that even moderate supplementation (0.5-2.0%) may be sufficient for hepatoprotection, particularly when the intervention is sustained over longer periods.

5.4 Practical Implications

The findings of this study have several practical implications for poultry nutrition and health management. First, the demonstration that baker's yeast supplementation significantly improves liver and kidney function in newly hatched chicks supports its use as a functional feed additive during the critical first two weeks post-hatch. This period is associated with high mortality rates in commercial operations, and interventions that support organ function could improve survival and long-term productivity.

Second, the dose-response patterns observed suggest that 2-4% yeast supplementation provides optimal benefits across most parameters. While 2% was most effective for AST reduction and 4% for ALP reduction, the differences were relatively small, and both levels produced substantial improvements in ALT, urea, and creatinine. The 6% level showed mixed results—superior for bilirubin but possibly inducing mild biliary stress as suggested by ALP elevation. Therefore, supplementation at 3-4% may represent the best balance of efficacy and safety.

Third, the cost-effectiveness of yeast supplementation must be considered. Commercial baker's yeast prices vary, but even at 2-4% inclusion, the additional feed cost may be justified by improved chick health and reduced mortality. Producers should conduct economic analyses specific to their operations, considering baseline mortality rates, the cost of yeast, and the value of improved chick survival and growth.

Fourth, the consistent improvements observed across multiple biomarkers suggest systemic effects of yeast beyond simple nutritional supplementation. This supports the classification of *Saccharomyces cerevisiae* as a functional food or nutraceutical in poultry nutrition, rather than merely a protein source.

6. Conclusion and Recommendations

6.1 Summary of Findings

This study evaluated the effects of dietary supplementation with baker's yeast (*Saccharomyces cerevisiae*) at three concentrations (2%, 4%, and 6% per kg diet) on liver and kidney function in newly hatched chicks over a 14-day experimental period. The major findings can be summarized as follows:

1. **Hepatoprotective Effects:** All yeast-supplemented groups showed significant reductions in serum ALT and AST activities compared to controls, indicating improved hepatocellular integrity. ALT decreased by 27-37%, while AST decreased by 19-31%. Total bilirubin decreased progressively with increasing yeast levels, reaching a 36% reduction in the 6% group. ALP showed optimal reduction at 4% yeast.
2. **Nephroprotective Effects:** Yeast supplementation produced dramatic reductions in serum urea (38-63% decreases) and creatinine (49-60% decreases), suggesting improved glomerular filtration and renal excretory capacity. The 2% yeast group showed the most pronounced renal benefits. Uric acid showed numeric but not statistically significant reductions.
3. **Optimal Supplementation Level:** The optimal yeast concentration varied by parameter, with 2% most effective for AST reduction, 4% for ALP and ALT reduction, and 6% for bilirubin handling. For renal parameters, 2% was superior. A moderate level of 3-4% likely provides the best balance of benefits across all organ functions.

4. **Mechanisms:** The observed improvements are attributed to the antioxidant, anti-inflammatory, and prebiotic properties of yeast cell wall components (beta-glucans, mannan-oligosaccharides) and the nucleotide content supporting cellular regeneration.

6.2 Conclusions

Based on the findings of this study, the following conclusions are drawn:

1. Dietary supplementation with baker's yeast at levels of 2-4% effectively enhances both liver and kidney function in newly hatched chicks during the critical first 14 days post-hatch.
2. Baker's yeast exerts significant hepatoprotective effects, as evidenced by normalization of serum transaminase activities and bilirubin levels.
3. Baker's yeast provides substantial nephroprotective benefits, particularly in reducing serum urea and creatinine concentrations, indicating improved renal function.
4. The 2% supplementation level is sufficient for most renal and hepatic benefits, with higher levels (4-6%) providing additional advantages for specific parameters but potentially introducing mild biliary stress at 6%.
5. *Saccharomyces cerevisiae* represents a promising natural alternative to synthetic feed additives and antibiotics for supporting organ health in young poultry.

6.3 Recommendations

6.3.1 Practical Recommendations for Poultry Industry

1. **Supplementation Protocol:** It is recommended that commercial poultry operations incorporate baker's yeast at 2-4% of the starter diet for the first 14 days post-hatch to support liver and kidney health during the critical transition period.
2. **Product Selection:** Producers should use active dry baker's yeast with guaranteed viability ($\geq 1 \times 10^{10}$ CFU/g) and documented beta-glucan content to ensure consistent efficacy.
3. **Monitoring:** Where possible, serum biochemistry monitoring should be implemented in research flocks to verify the expected improvements in liver and kidney biomarkers.
4. **Combination Strategies:** Baker's yeast supplementation may be combined with other nutraceuticals (e.g., selenium, vitamin E, herbal extracts) for potential synergistic effects on organ function.

6.3.2 Recommendations for Future Research

1. **Mechanistic Studies:** Research should investigate the molecular mechanisms underlying yeast-induced hepatoprotection and nephroprotection, including gene expression analysis of antioxidant enzymes, inflammatory cytokines, and detoxification pathways.
2. **Long-Term Studies:** Investigations should extend beyond 14 days to determine whether early yeast supplementation produces lasting benefits on liver and kidney function throughout the grow-out period and whether it affects final product quality.
3. **Dose Optimization:** More refined dose-response studies with additional intermediate levels (e.g., 1%, 3%, 5%) are needed to precisely identify optimal supplementation levels for different production objectives.
4. **Comparative Studies:** Direct comparisons between different yeast products (live yeast, inactivated yeast, yeast cell wall extracts, yeast hydrolysates) would help identify the most efficacious formulations.

5. **Stress Models:** Research should evaluate the protective effects of baker's yeast under various stress conditions including heat stress, mycotoxin challenge, and disease exposure to understand the full range of benefits.
6. **Histopathological Confirmation:** Histological examination of liver and kidney tissues should be conducted in future studies to confirm that biomarker changes correspond to structural improvements in organ architecture.
7. **Economic Analysis:** Comprehensive cost-benefit analyses should be conducted to determine the economic viability of yeast supplementation in commercial production settings.

6.4 Limitations of the Present Study

Several limitations of this study should be acknowledged. First, the sample size of six birds per group, while adequate for detecting large differences in the measured parameters, may have been insufficient to detect more subtle effects or to definitively characterize dose-response relationships. Second, the 14-day experimental period, while appropriate for the early post-hatch window, does not provide information about longer-term effects or the persistence of benefits beyond the supplementation period. Third, the study was conducted under controlled research conditions that may not fully represent the challenges encountered in commercial production including variable environmental conditions, disease pressure, and management practices. Fourth, only serum biomarkers were assessed; histopathological examination of liver and kidney tissues would provide complementary information about structural changes corresponding to the functional improvements observed. Fifth, the study did not include growth performance parameters; future research should evaluate whether improved organ function translates to enhanced weight gain, feed conversion, and reduced mortality.

6.5 Final Remarks

This study provides robust evidence that dietary supplementation with baker's yeast at 2-4% significantly enhances liver and kidney function in newly hatched chicks. The hepatoprotective and nephroprotective effects observed across multiple biomarkers strongly support the use of *Saccharomyces cerevisiae* as a functional feed additive during the critical early post-hatch period. As the poultry industry continues to seek natural, effective alternatives to antibiotics and synthetic compounds, baker's yeast offers a scientifically validated, cost-effective option for supporting chick health and laying the foundation for optimal lifetime productivity. Further research building on these findings will help refine supplementation protocols, elucidate underlying mechanisms, and expand the applications of yeast-based interventions in poultry health management.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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