Research Article

The Impact of *Saccharomyces cerevisiae* on Growth Performance of Rabbit: A Meta-Analysis

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Abstract | The growing demand for sustainable protein sources and ban of growth promoters have sparked interest in alternative methods. Rabbit farming is a promising option because of prolific reproduction, efficient feed consumption, and adaptability to various environments. The use of *Saccharomyces cerevisiae* (*S. cerevisiae*), offers an intriguing possibility for enhancing rabbit performance. The objective of this meta-analysis is to resolve the current inconsistent and scattered evidence of its effectiveness. This meta-analysis conducted via OpenMEE software using the available literature, reveals that *S. cerevisiae* positively influences the weight gain of rabbits, with a pooled standardized mean difference of 0.591 (95% confidence interval: -0.024 to 1.206, p= 0.060). However, the impact on the feed conversion ratio (FCR) is not statistically significant, with a pooled estimate of -0.126 (95% confidence interval: -0.580 to 0.328, p= 0.586). These results suggest that supplementation with *S. cerevisiae* improves body weight gain in rabbits. Nevertheless, the data do not support a clear conclusion regarding its effect on FCR. This results shed light on the potential of *S. cerevisiae* as a growth stimulant and emphasize its role in promoting sustainable farming. Future investigations should address the underlying factors that contribute to the observed variation to fully comprehend the extent to which the addition of *S. cerevisiae* can enhance the performance, health and FCR, and well-being of rabbits.

Keywords | Feed conversion ratio, Feed supplementation, Rabbit productivity, Saccharomyces cerevisiae, Sustainable protein sources

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INTRODUCTION

The rising demand for meat and protein in resource-constrained regions is on the watch for alternative hopeful solutions and rapid sources of supply, one of which is rabbit farming (Abdel-Rahman and Ashour, 2023; Johnson *et al.*, 2024; Ayeni *et al.*, 2023). Rabbit prolific reproduction ability, lower input dependency,

efficient feed consumption, adaptability to environmental extremes, and the ability to cope with high-fiber diets make them an economical and sustainable approach to provide protein supply, particularly in underdeveloped and heat-stressed regions (Peixoto-Gonçalves *et al.*, 2023; Nicula–Neagu *et al.*, 2023; Liu *et al.*, 2023; Abdelsalam *et al.*, 2023). However, maximizing feed and nutrition is critical to effectively maximizing rabbit production, feed conversion, and ultimately economic benefits (Ayoola *et al.*, 2024; Bashar *et al.*, 2023; Setiaji *et al.*, 2022). In this context, supplementing diets with *Saccharomyces cerevisiae* (*S. cerevisiae*), a kind of yeast that enhances nutrient availability and absorption, is an exciting approach to boost rabbit performance, economic turnover, and welfare (Al-Sagheer *et al.*, 2023; Elbaz *et al.*, 2023).

The inclusion of *S. cerevisiae* in rabbit diets has great potential owing to its numerous health benefits, feed utilization, nutrition digestibility, and capacity to improve animal production (Kalma *et al.*, 2016; Mancini and Paci, 2021). The use of growth promoters and antibiotics, and their drawbacks, have prompted researchers to seek effective and environmentally sustainable alternatives. One of the alternatives is *S. cerevisiae* as a promising candidate (Elghandour *et al.*, 2020; Falcão-e-Cunha *et al.*, 2010). The level of effectiveness of *S. cerevisiae*, however, has been in doubt as a result of substantial disparities across studies, many of which have a significant positive influence on body weight gain (532 g difference between control and experimental groups) and improved feed conversion ratio, while others disclose minimal to no significance on weight gain (176 g loss between control and treatment groups) and feed conversion ratio (Shehu *et al.*, 2014; Emmanuel *et al.*, 2019; Ahmed *et al.*, 2019). One likely reason for the disparity in conclusions is the dose of *S. cerevisiae* administered and the duration of treatments; however, not a single study has been able to address this correlation so far.

Meta-analysis provides a systematic approach to characterize the cumulative effect of dose-dependent and age-related yeast supplementation on key rabbit outcomes, such as body weight gain (BWG), feed conversion ratio (FCR), and weight increase, providing useful insights for informed choices in rabbit farming. Meta-analysis can offer helpful information on the overall efficacy of *S. cerevisiae* supplementation across various research studies, with a focus on age- and dose-sensitive performance, promoting evidence-based decision-making, and steering future research directions in rabbit farming. This study aimed to systematically evaluate the effects of *S. cerevisiae* supplementation on rabbit growth performance using a meta-analytical approach. By identifying consistent patterns and dose-age interactions across published studies, this meta-analysis seeks to provide evidence-based recommendations for optimizing rabbit nutrition and enhancing farming efficiency.

MATERIALS AND METHODS

Literature search and inclusion criteria

The literature search was conducted in National Center for National Center for Biotechnology Information, and Google Scholar by using the keywords "*Saccharomyces cerevisiae*" "rabbit" "body weight" "performance," the literature was then screened/reviewed by all the authors. In order to qualify the research manuscripts had to be (1) original research (not a review or conference abstract), (2) Written in English, (3) full-text publications, (4) rabbit animal trials, (5) must have control reports, (6) direct use of *S. cerevisiae* without enzyme or carbohydrate addition, and (7) reports of body weight and feed conversion ratio in control and experimental trials. A total of 159 results were obtained initially from NCBI and after screening and removing the double, reviews, and non-animal trials, 7 papers were finalized for analysis along with 8 from Google Scholar, and the data extraction was performed as follows (Figure 1).

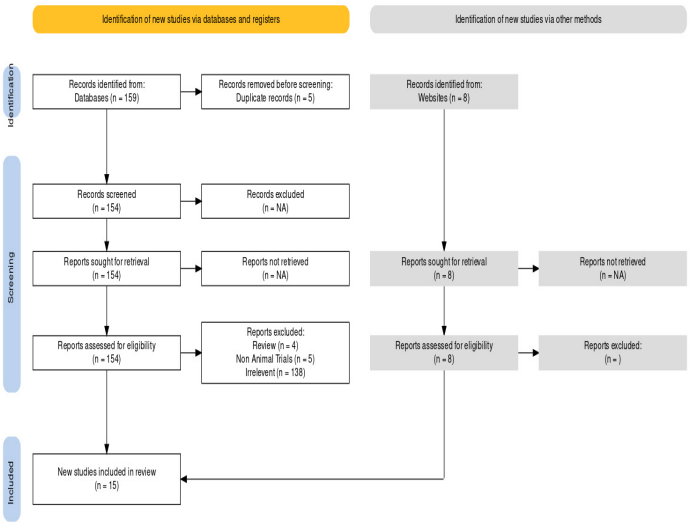

Figure 1: PRISMA-P flowchart for identification, retrieval and eligibility of literature from NCBI and Google Scholar.

Data extraction

The dataset was prepared in Microsoft Excel, with means of first author, publication year, breed, control, and experimental trials for the BWG and FCR parameters of experimental and control animal groups (Figure 2). The measure of variability in the literature was in the form of standard deviation, standard error of the mean, confidence interval, or mean square error, but was all homogenized in the form of standard deviation.

Figure 2: The selected studies for meta-analysis showing first author, publication year and the breed of rabbit used in the study.

Meta analysis

The meta-analysis was conducted using OpenMEE build date 2016-07-26 software by utilizing a continuous random-effects model with the DerSimonian-Laird method. The effect size was calculated by using Hedges' d as follows:

$$d = \frac{X^E - X^C}{S_I}$$

Where X^E represents pooled observations from experimental groups (with *S. cerevisiae* supplementation), and X^C represents pooled observations from control groups with S_J as a small sample size correction factor.

RESULTS AND DISCUSSION

The meta-analysis assessed the effect of *S. cerevisiae* supplementation on rabbit body weight gain using a continuous random-effects model with the DerSimonian-Laird method. The pooled standardized mean difference (SMD) was 0.591, with a 95% confidence interval (CI) of -0.024 to 1.206 and a p-value of 0.060. This indicated a potential positive effect of yeast supplementation on BWG, although the results were statistically significant. Heterogeneity among the studies was substantial, with an I^2 value of 93.08%, suggesting considerable variability across the included trials. The forest plot (Figure 3) shows the individual study effects, their confidence intervals, and the overall pooled estimate, with larger squares representing studies with a greater statistical weight. For FCR, the pooled SMD was -0.126 (95% CI: -0.580–0.328), with a p-value of 0.586, indicating that S. cerevisiae supplementation had no statistically significant effect. Heterogeneity remained high (I^2 = 88%), reflecting notable variability among studies. The forest plot (Figure 4) illustrates individual and pooled effects. The diamond representing the overall estimate lies slightly left of the null line, suggesting a trend toward improved FCR but without statistical support.

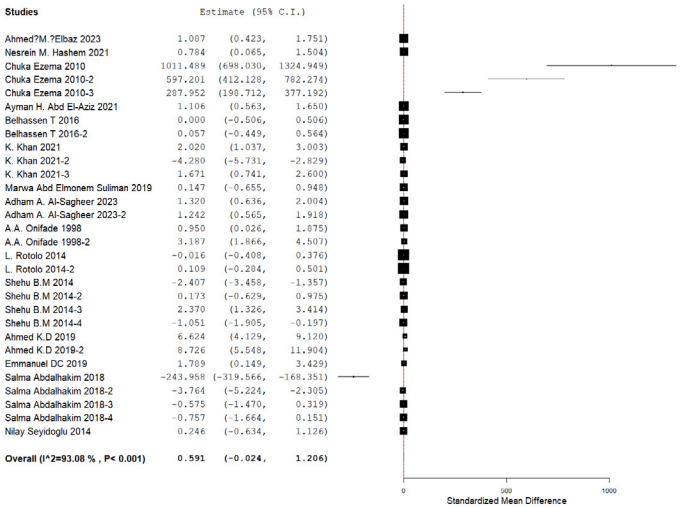

Figure 3: Forest plot showing the effect of *Saccharomyces cerevisiae* supplementation on body weight gain in rabbits

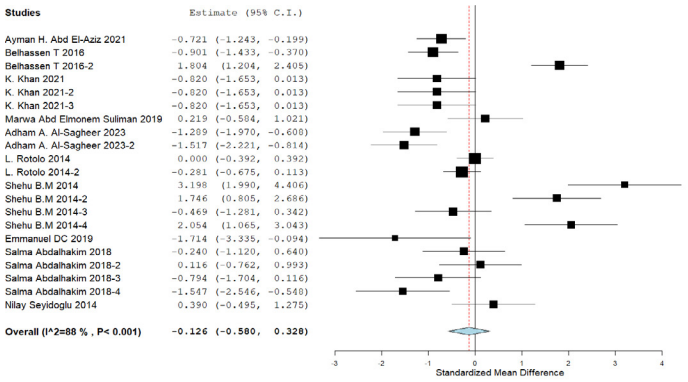

Figure 4: Forest plot showing the effect of *Saccharomyces cerevisiae* supplementation on feed conversion ratio in rabbits.

The findings of this meta-analysis suggest that dietary supplementation with *S. cerevisiae* may positively influence BWG in rabbits. Although the pooled effect size was moderate (SMD= 0.591), the p-value (0.060) indicated a borderline statistical significance. This suggests a promising yet cautious optimism toward the efficacy of yeast supplementation in improving growth performance in rabbits. This effect is likely attributable to the role of yeast in enhancing gut health, stabilizing intestinal microflora, and improving nutrient digestibility and absorption factors that directly contribute to BWG (Henderickx *et al.*, 2019).

In contrast, *S. cerevisiae* supplementation did not produce a statistically significant effect on the feed conversion ratio (SMD= -0.126, p = 0.586). Despite a slight trend toward improved FCR, evidence does not robustly support its influence on feed efficiency. This contrasts with several earlier studies that reported improvements in FCR with yeast inclusion, pointing to inconsistencies in outcomes across the literature (Abd El-Aziz *et al*., 2021; Belhassen *et al*., 2016; Rotolo *et al*., 2014). One possible explanation for these inconsistencies is the substantial heterogeneity observed across both analyses (93.08% for BWG and 88% for FCR). These factors likely interact in complex ways, influencing the metabolic and physiological responses of rabbits to dietary supplementation.

Body weight gain

The alluvial diagram provides a visual synthesis of the interplay between experimental factors, namely, age, dosage of *S. cerevisiae*, and their cumulative effect on rabbit performance (Figure 5). This complements the meta-analysis findings by offering a more detailed view of variability and conditional responses in the literature. Overall, the trend in the plot supports the meta-analytical results, suggesting a positive influence of *S. cerevisiae* supplementation on rabbit BWG. Several treatment groups demonstrated a clear improvement in total body weight compared with their control counterparts. This aligns with the known mechanisms by which *S. cerevisiae* improves nutrient utilization, stabilizes gut flora, and boosts the immune response, thereby supporting growth performance. The most notable trend in the plot is the dose-dependent nature of the response. Rabbits supplemented with 0.5 g to 1.5 g of *S. cerevisiae* per day exhibited the most consistent and pronounced increases in body weight, as indicated by thicker, uninterrupted flow lines toward higher BW values (e.g., 2040 g, 2177 g). In contrast, extremely low or high doses resulted in mixed outcomes, with some studies reporting little to no gain or even lower final weights than the control groups. This suggests a threshold beyond which additional yeast does not translate to further benefits, likely due to the saturation of microbial or metabolic responses (Hackett *et al*., 2016).

Another visible pattern is the effect of rabbit age on the effectiveness of yeast supplementation. The age groups between 6-10 weeks appear more responsive to supplementation, as indicated by denser lines, leading to improved BWG outcomes. This supports previous findings that mid-growth phases may offer an optimal physiological window for benefiting from functional feed additives owing to rapid gut development and high nutrient demand (Aftab *et al*., 2018). Despite the positive trend, the figure also illustrates inter-study variability, with similar doses and age groups yielding different results in the different experiments. This reflects the heterogeneity quantified in the meta-analysis (I^2= 93.08%). Potential reasons for this include breed differences, environmental stress, baseline diet composition, health status, and experimental design. Even at identical doses (e.g.,1g/day), final body weights ranged from below 1,900g to above 2,100g, indicating a significant influence of external or unreported factors. Importantly, this visual evidence helps reconcile previous contradictory findings, such as those of Shehu *et al*. (2014), who reported lower weight gain under yeast supplementation. By aggregating multiple datasets, the plot highlights that despite some variability, the overall trend indicates improved body weight, reinforcing the general efficacy of *S. cerevisiae* supplementation when used under optimized conditions.

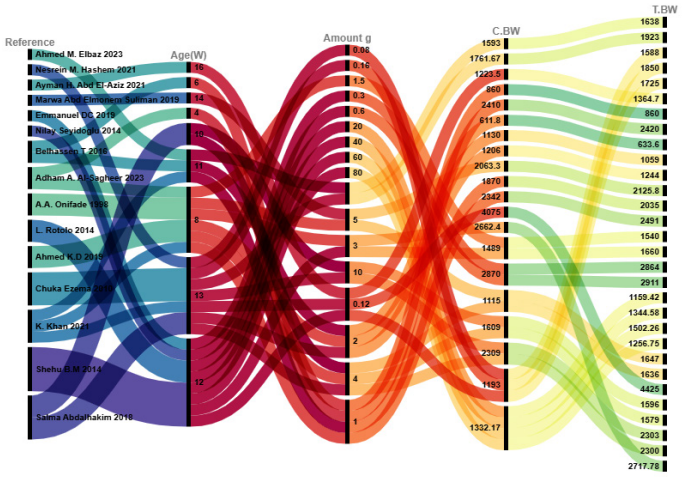

Figure 5: Alluvial illustration showing the trends in treatment body weight under influence of age, breed, and the amount of *Saccharomyces cerevisiae.*

Feed convertion ratio

The alluvial plot illustrates the intricate relationships between various experimental factors, including age, breed, and dosage of *S. cerevisiae,* and their influence on rabbit FCR (Figure 6). This visualization complements the meta-analysis by revealing nonlinear, context-dependent trends that may explain the high heterogeneity observed among studies. The diagram shows that different breeds, such as New Zealand White, New Zealand × Local crosses, and other heterogeneous lines, responded differently to yeast supplementation. New Zealand White rabbits appeared frequently across studies; however, their FCR outcomes varied depending on age and dosage. Notably, younger rabbits (4-6 weeks) tended to show more variable responses than older ones (8-12 weeks), suggesting that age may mediate digestive efficiency and microbial adaptation to yeast-based diets. These findings are in line with previous reports by Zheng *et al*. (2021), which suggested that the gut microbiota stabilizes with age, potentially influencing the efficacy of prebiotic additives.

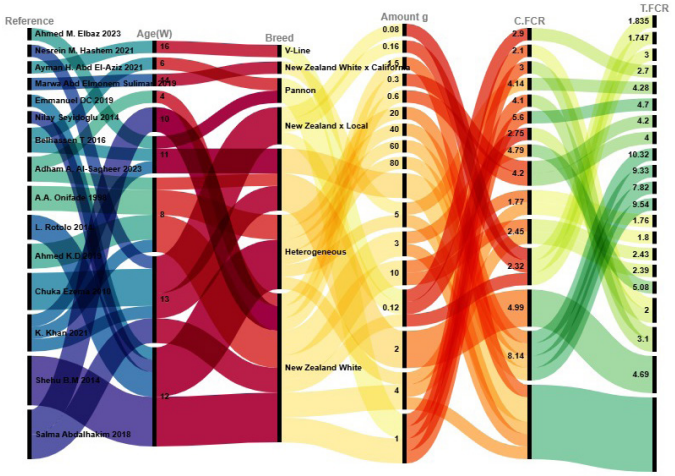

Figure 6: Alluvial illustration showing the trends in treatment feed conversion ratio under influence of age, breed, and the amount of Saccharomyces Cerevisiae.

A central trend revealed by the plot is that moderate yeast doses (e.g., 0.5 g to 1.0 g per rabbit/day) were more consistently associated with improved or neutral FCR values, while very low or high doses produced more scattered and inconsistent results. with 1.0 g was frequently correlated with better FCRs (3.86-3.97), particularly in standardized breeds. This highlights the potential of an optimal dose window beyond which no further benefits or even negative effects may be observed. This dose-dependent effect aligns with earlier research in ruminants and poultry, where excessive yeast supplementation disrupted microbial equilibrium rather than enhancing it (Chae *et al*., 2024). Some studies using the same breed and similar age groups have shown divergent FCR outcomes, further reinforcing the role of unaccounted environmental or methodological differences. Factors such as ambient temperature, baseline feed composition, and stress levels might confound the results (Kierman *et al*., 2023), thereby contributing to the high heterogeneity (I^2= 88%) found in the meta-analysis. While the meta-analysis statistically confirmed no significant effect of *S. cerevisiae* on FCR, the alluvial plot confirms this conclusion by revealing patterns that suggest conditional improvements, particularly at optimal dosages and in specific breed-age combinations. This underlines the importance of moving beyond simple effect size reporting toward multifactorial interpretations of performance data.

CONCLUSION

This meta-analysis provides evidence that *S. cerevisiae* supplementation in rabbit diets has a positive effect on body weight gain, although its effect on the feed conversion ratio remains inconclusive. These findings support its use as a potential natural growth enhancer for rabbit production. Future studies should focus on it's influence on health, well-being of rabbits, and other performance and efficacy optimizations.

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NOVELTY STATEMENT

This is the first of it's kind meta-analysis of *Saccharomyces cerevisiae's* influence over the rabbit growth performance. It focuses on age and breed-specific trends in rabbit performance under *Saccharomyces cerevisiae's* supplementation.

AUTHOR'S CONTRIBUTION

Conceptualization: Asep Setiaji, Faheem Ahmed Khan; Methodology: Mohammad Miftakhus Sholikin; Data Analysis: Bilal Ahmed, Muhammad Rizwan Yousaf; Validation: Nuruliarizki Shinta Pandupuspitasari; Writing manuscript-original: Bilal Ahmed, Muhammad Rizwan Yousaf; Writing manuscript-review/revision: Bilal Ahmed, Mohammad Asif Raza, Sugiharto Sugiharto; others: Asep Setiaji.

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Generative AI or AI-assisted Technology Statement

The authors declare that no Genrative AI was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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