J. of Animal and Poultry Production, Mansoura Univ., Vol. 15 (12):189 - 197,2024

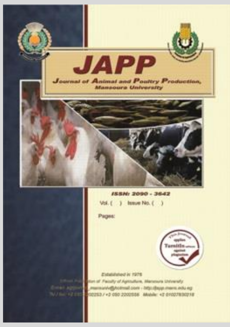
Journal of Animal and Poultry Production

Journal homepage & Available online at: www.jappmu.journals.ekb.eg

Productive and Reproductive Performance of Doe Rabbits Fed Diets Supplemented with Spirulina, Yeast, and *Bacillus subtilis* as Natural Additives

Abdou, A. A. *; Shama H. A. Morsy and M. R. M. Mostafa

Deprments of Animal Nutrition Res., Animal Production Research Institute, Agricultural Research Centre, Dokki, Giza, Egypt



ABSTRACT

This study was designed to investigate the effects of dietary adding *Spirulina platensis* (SP), live yeast (LY), and *Bacillus subtilis* (BS) on nutrient digestion, and the productive and reproductive performances of doe rabbits. Forty healthy doe rabbits aged nine months and weighing 3223±5 g were used for a 75 - day experimental period and split into four similar experimental groups according to their live body weight. Rabbits were fed a pelleted diet free from probiotics (control group, T1), while T2, T3, and T4 groups received the same diet supplemented with 1 g SP/doe/day, 1 g LY/doe/day, and 0.5 g BS/doe/day, respectively. Results showed a significant ($p<0.05$) increase in milk yield in T4 but didn't influence feed intake or live body weight of rabbits. All nutrient digestibility coefficients were the highest in T2. Most productive and reproductive performances of does had significantly enhanced in probiotic groups. Supplementation with probiotics significantly increased serum total protein, albumin, and globulin concentrations, while serum urea and creatinine concentrations appeared to be significantly ($p<0.05$) lower. Generally, the results obtained revealed that using SP, LY, and BS as feed additives in rations of doe rabbits, have positive effects on the productive and reproductive performance traits and economic feed efficiency. These supplements could be used as natural feed additives to improve the health status as well as the productive and reproductive performances of doe rabbits.

Keywords: Probiotics, rabbits, nutrient digestion, blood parameters, litter size

INTRODUCTION

Probiotics are demonstrated to be an effective alternative to antibiotics for livestock producers, improving the productive performance and health status of animals (Kiczorowska et. *al.*, 2017). They also help support intestinal health by promoting good bacterial growth and producing chemical compounds to fight pathogenic bacterial growth (Sokale *et al.;* 2019; Liu *et al.* 2019). As explained by Krieg *et al.* (2010), gut microbiota plays a vital role in preserving gut health system by maintaining ecological intestinal structure and its function, which results in enhanced nutrients digestion and absorption (Zhang *et al.*, 2019).

On the other hand, several studies documented the effectiveness of spirulina, yeast, and B. subtilis in improving animal performance without any harmful effects on rabbit health (Guo *et al.*, 2017; Shen *et al.*, 2018; Abdou *et al.*, 2024). Specifically, Bacillus species are bacteria that are highly safe and more effective in animal nutrition (EFSA, 2013). Moreover, Sanders *et al.* (2003) reported that Bacillus species can generate substances important as growth promoters such as vitamin K, B12 and amino acids and consume oxygen in the gut, leading to increases in the number of anaerobic bacteria (Zhou *et al.*, 2013). Earlier studies observed that B. subtilis can enhance nutrient digestibility coefficients and improve growth performance as well as enhancing the immune system of rabbits (Makarenko *et al.*, 2019), by increasing the beneficial of the lactic acid bacteria relative to the harmful one (Guo *et al.* 2017).

In animal nutrition, yeast is popularly used as a probiotic agent to improve the productive performance and overall health of animals (Ayyat *et al.*, 2018). Furthermore, spirulina in animal feeding has good nutritional and functional properties due to its high-quality vital compounds and health-promoting properties (Marquez- Rocha *et al.*, 1995). In addition, many studies have indicated that feeding on different probiotic species to experimental rabbits improved well-being, enhanced productive performance, and a decreased mortality rate (Makarenko *et al.*, 2019; Simonová *et al.*, 2020; Abd El-Aziz *et al.*, 2021; Abdou *et al.*, 2024). Thus, this study aimed to evaluate the impact of spirulina, live yeast, and Bacillus subtilis supplementation on nutrient digestibility coefficients, certain parameters in the blood, and the productive and reproductive performance of doe rabbits.

MATERIALS AND METHODS

Ethical Statement

This study was conducted at Sakha Animal Production Research Station, Animal Production Research Institute (APRI), Agricultural Research Centre, Ministry of Agriculture, Egypt. All implementation measures were taken to reduce animals suffering and safe the welfare conditions throughout the trial.

Feeding trail:

Forty New Zealand doe rabbits, having nine months of age and weighing an average LBW of 3223±5 g, were used for 75 days experimental period, chosen and randomly distributed to four similar groups of ten each, based on their LBW. Rabbits were fed a pelleted diet free from probiotics

* **Corresponding author.**
E-mail address: aliahmedabdou@arc.sci.eg
DOI: 10.21608/jappmu.2024.330324.1136

(control group, T1), while T2, T3, and T4 groups received the same diet supplemented with 1 g SP/doe/day, 1 g LY/doe/day and 0.5 g BS/doe/day, respectively. Spirulina is obtained from the National Institute of Oceanography and Fisheries (NIOF), in Egypt, which reports its chemical composition was 55.80, 6.20, 4.90, 23.00, and 10.10% for CP, EE, CF, NFE, and ash, respectively. While, like yeast additive have contained $2x10^9$ cfu/g for *Bacillus subtilis*. The formulation and chemical composition of conventional ration are shown in Table 1. Rabbits were covered accurately the nutrient requirements according to NRC (1977). During the trial period, doe rabbits were housed individually in galvanized metal wire cages. The drinking fresh water was available via automatic nipple drinkers. All doe rabbits were preserved in the same administrative and hygienic trial conditions. Ingredients and chemical analysis of belted diet are shown in Table (1).

Digestibility trials:

Four digestibility trials were carried out at the end of the feeding trial on three rabbits from each group. The digestion experiment lasted 10 days, which as a preliminary period of 7 days and 3 days as collection period. Both feed and feces were collected quantitatively and recorded daily, individually for each doe, through the collection period. The various samples were chemically analyzed for CP, CF, EE, and ash according to AOAC (2005) after 48 hour drying period at 60ºC in a forced air oven.

Table 1. ingredients and chemical analysis of basal diet.

Ingredient	%	Chemical analysis (% as DM):	%
Berseem hay	30.25	Dry matter (DM)	85.81
Barley grain	24.60	Crude protein (CP)	17.36
Wheat bran	21.50	Organic matter (OM)	91.42
Soybean meal (44% CP)	17.50	Crude fiber (CF)	12.37
Molasses	3.00	Ether extract (EE)	2.230
Limestone	0.95	Digestible energy (DE,kcal/kg)**	2412
Di-calcium phosphate	1.60	Calcium	1.243
Sodium chloride	0.30	Total phosphorus	0.808
Mineral-vitamin premix*	0.30	Lysine	0.862
Total	100	DL-Methionine	0.632

*** One kilogram of mineral–vitamin premix provided: Vitamin A, 150,000 UI; Vitamin E, 100 mg; Vitamin K3, 21mg; Vitamin B1, 10 mg; VitaminB2, 40mg; Vitamin B6, 15mg; Pantothenic acid, 100 mg; Vitamin B12, 0.1mg; Niacin, 200 mg; Folic acid, 10mg; Biotin, 0.5mg; Choline chloride, 5000 mg; Fe, 0.3mg; Mn, 600 mg; Cu, 50 mg; Co, 2 mg; Se, 1mg; and Zn, 450mg.** Calculated according to De Blas and Mateos (1998).**

Productive and reproductive traits:

Live body weight (LBW) and weight changes for each doe were recorded during different trial periods. The conception rate (CR), the size and weight of litter from birth to weaning (LSB and LWW), and the mortality rate (MR) was calculated as the following equations:

Mortality rate (%) = [(number of kids at birth – number of kids at weaning) /number of kids at birth] x 100

The feed intake (FI) of pelleted diet was recorded, and then feed conversion ratio (FCR) was calculated as the following:

FCR = Daily feed intake (g) / daily weight gain (g) of litter

Milk intake by kids (MY) was determined by the kid weight differences prior and following suckling for 24 hours twice a week.

Blood parameters:

Blood samples were taken in clean tubes from the ear veins of three does in each group, at the end of the experimental period. Blood samples were allowed to clot, then a clear serum was separated by centrifugation at 4000 rpm for 20 minutes and kept in a deep freezer at 20 ^{0}C till the time of analysis.

Biochemical parameters were determined in serum using commercial kits of Bio-Merieus Lab, France in accordance with the manufacturer's instructions. Total protein (TP), albumin (Al), urea, and creatinine levels were estimated employing the techniques of (Henry *et al.,* 1974; Doumas *et al.,* 1971). The globulin (Gl) level was determined by positing the Al level from the TP level. The liver enzyme aspartate aminotransferases (AST) and alanine aminotransferases (ALT) levels were analysis using trade kits based on the methods of Reitman and Frankel (1957).

Statistical analysis:

The data were statistically analyzed using SAS (2003) program, General Linear Model's technique. A one–way analysis was carried out to assess the impact of the addition of various probiotics on the tested parameters by using the following model: $Y_{ij}= \mu+T_i+E_{jj}$,

Where: Y_{ij} = the observation of the parameter measured, μ = the overall means, T_i = the effect of dietary treatment, (i= 1.2,3 and 4) and E_{ij} = the random error. Differences between means among all treatments were subjected to Duncan's Multiple Range– test Duncan (1955).

RESULTS AND DISCUSSION

Digestibility of nutrients:

All digestibility nutrients and feeding values of SP-ration were significantly (P<0.05) higher than those of the control one, except for NFE digestibility which recorded higher digestibility with no significant differences (Table 2). The highest values were associated with the T2 group followed by the T4 and T3 groups, whereas the lowest one occurred with the T1 group.

This favorable impact of SP supplement on digestibility nutrients is due to its high levels of unsaturated fatty acids, polysaccharides, carotenoids, growth factors, and β- glucan, which contribute to enhanced gut biodiversity and increased lactic acid bacteria numbers, according to Kholif *et al.* (2017) and Gomaa *et al.* (2018). These results are in agreement with those obtained by Amer *et al.* (2016) and Mahmoud *et al.* (2017), except for the reduction of CF and EE digestibility, respectively. Moreover, El-Deep *et al.* (2021) found that adding higher levels of *Aspergillus awamori* significantly improved CP, CF, and EE digestibility coefficients compared to the low level and control. A more recent study confirmed the positive effect of SP on nutrient digestibilities and nutritive values, as reported by Abdou *et al.* (2024) who added three levels of spirulina in rabbit diets. Otherwise, our findings didn't agree with those published by Peiretti and Meineri (2008) which suggested that spirulina supplementation in growing rabbit rations negatively affects nutrient digestibility. On the other hand, adding BS significantly (P<0.05) improved OM, CF, and CP digestibility coefficients and the nutritive value relative to the control one, with no notable differences in other nutrients. While adding LY led to somewhat improved nutrients digestibility and the nutritive values than that of the control one. Likely, the addition of probiotics can help support nutrient digestibility coefficients by encouraging digestive enzyme release (Hu *et al.*, 2018). Additionally, it enhances the fermentation activity and gut structure adjusting, thereby increasing of homeostasis and overall gut function (Cartman *et al*., 2008; Gu *et al*., 2015; El-Deep *et al.,* 2021). Likewise, they can also improve nutrient absorptions across the intestinal barrier (Machida *et al.,* 2005), activate the gut microbiota, improve the immune system, and boost gut mucosa structure (Rawski *et al.,* 2016; Elghandour *et al.,* 2019). These results were in line with those of Bhatt *et al.* (2017) and Elmasry *et al*. (2021), who stated that the addition of probiotics could improve all or some of nutrient digestibility coefficients. Likewise, another study on rabbits that conducted by El-Badawi *et al.* (2017), who found that the digestibility of nutrients was improved by adding yeast or BS compared to that of combination group (LY plus BS) and control one. However, yeast addition showed a slight effect on nutrient digestibility and nutritive values; the reason for this is not clear. Similarly, the results of Tag El Din *et al.* (2019) confirmed that supplementing yeast in rabbit rations didn't influence the digestibility of nutrients, except for crud fiber digestibility, which appeared to an improvement. Additionally, earlier results of Phuoc and Jamikorn (2017) found that nutrient digestibility coefficients with weaned rabbits were unchanged after fed dietary BS. Furthermore, Fathi *et al.* (2017) observed that the positive effects of probiotics on nutrient digestibility coefficients depend on some factors like kind, doses and duration of their use.

Table 2. Effect of probiotic supplementation on nutrient digestibility and feeding values of the experimental diets.

Item	Experimental diet				
	T1	T2	T3	T4	SEM
Digestion coefficients (%):					
DM	61.80^{b}	64.95^{a}	63.55^{ab}	64.56^{ab}	0.82
OM	62.67^{b}	66.10^{a}	64.89^{ab}	65.45^{a}	0.72
CP	71.88^{c}	78.36^{a}	73.56^{bc}	75.09^{b}	0.63
CF	21.84^{b}	24.95^{a}	23.54^{ab}	24.53^{a}	0.60
EE	74.80^{b}	79.45^{a}	77.80^{ab}	77.90^{ab}	0.97
NFE	78.20	81.94	81.05	81.90	1.16
Feeding values (%, DM basis):					
TDN	62.70^{b}	66.53^{a}	64.42^{ab}	65.82^{a}	0.68
DCP	12.50^{c}	13.63^{a}	12.80^{bc}	13.07^{b}	0.11

SEM = Standard error of means a, b and c: Means within rows with different superscript are significantly different (P<0.05). T1: control group; T2: 1 g of SP/h/d; T3: 1g of LY/d/h; T4:0.5 g of BS /h/d.

Feed intake:

Results obtained in Table 3, indicated that the additive supplementation had no significant impact on feed intake for pregnant and lactating does. These finding were consistent with the studies concluded by Seyidoğlu and Galip (2014), Tag El-Din (2019), Ribeiroa *et al.* (2020), Wang *et al.* (2020), Elmasry *et al.* (2021), and Colombino *et al.* (2022), which indicated the inclision of SP, *Nannochloropsis oceanica* or various probiotics in rabbit rations achieved comparable findings. However, the findings of Phuoc and Jamikorn (2017), Sikiru *et al.* (2019), and Abdou *et al.* (2024) found that supplementing probiotics, either alone or mixed with others, were appeared to be in contrast to our results. On the other hand, our results showed the daily feed intake through the lactation period increased by 44.84% compared to that of pregnancy period (Table 3), where such results are similar to the findings obtained by Amira M. Refaie *et al.* (2022).

Body weight changes:

During the different experiment stages, probiotic supplementation didn't significantly affect on rabbit body weight changes, except for the prepartum period, where weight changes in T2 and T4 groups showed significantly (P<0.05) higher than those of T1 group. The differences observed with the T3 group were not significant, as shown in Table 3. Moreover, there was a positive change in BW during gestation with the highest value in T4 followed by T2 then T3, but T1 had the lowest values. However, there was negative change in BW during lactation with the highest value in T1 followed by T3 and T2, while the lowest value recorded with T4.

These results are in line with those reported by Seyidoğlu and Galip (2014), Fathi *et al.* (2017), Emmanuel *et al.* (2019) and Tag El Din (2019),. Nevertheless, the findings of Wang *et al*. (2020), Elmasry *et al*. (2021), Abd El-Aziz *et al.* (2021), El-Deep *et al.* (2021), and Abdou *et al.* (2024), showed significant improvements in rabbit body weight after consuming probiotic rations. Moreover, during the lactation period, the lost body weight of rabbits in the experimented groups was -95.0,-103.3, and -84.2 g for T2, T3, and T4, respectively, compared to the - 118.3 g for the control ration (T1). These results were agreement with those reported by Abdou *et al.* (2024) after SP was added to the doe rabbit rations.

Table 3. Impact of experimental rations on the productive performance of does during gestation and lactation periods.

Item	Experimental diet				SEM
	T1	T2	T3	T4	
Feed intake (g/h/d):					
Pregnant does	182.7	175.0	188.9	179.5	6.42
Lactating does	264.0	251.5	270.5	265.6	11.70
Average	223.35	213.25	229.7	222.55	9.06
Doe weight (g):					
At mating	3273.3	3281.7	3274.2	3265.0	77.39
Pre-partum	3595.0^{b}	3697.5^{a}	3668.3^{ab}	3699.2^{a}	31.84
Partum	3268.3	3290.0	3285.0	3297.5	93.44
Weaning	3150.0	3195.0	3181.7	3213.3	93.22
Doe weight change (g):					
Mating - pre-partum	321.7^{c}	415.8^{ab}	394.2^{b}	434.2^{a}	58.78
Mating -partum	-5.0^{c}	8.3^{b}	10.8^{b}	32.5^{a}	1.16
Mating-weaning	-118.3^{a}	-95.0^{bc}	-103.3^{ab}	-84.2^{c}	3.33

SEM = Standard error of means $^{a, b, and c}$: Means in the same row with different superscripts are significantly different (P<0.05).
T1: control group; T2: 1 g of SP/h/d; T3: 1g of LY/d/h; T4:0.5 g of BS /h/d.

Milk yield (MY)

Data presented in Table 4 indicated that the dietary probiotic showed a significantly positive effect on milk yield during the 1st week. Additionally, during 2nd week, the T2 and T4 groups had significantly (P<0.05) higher milk yield compared to the T1 group, with no significant differences. Furthermore, the T2 and T4 groups recorded significantly (P<0.05) increased milk yield during 3rd week. In the 4th week, milk yield in the T4 group was significantly (P<0.05) greater than in the T1 group, with no significant differences observed between T2, T3 and T4 groups. Probiotic groups (T2, T3, and T4) appeared to higher milk yield as overall mean by 16.11, 11.26 and 18.50, respectively, based on the control group (T1).

The positive effect of SP on MY, might be due to its richness in bioactive compounds, including natural antioxidants along with other essential substances that enhance metabolic processes (Komoto *et al.,* 2018; Sharawy *et al.,* 2020). It also increased mRNA expression of glutathione peroxidases, which have antioxidant properties and help maintain animal health, productivity, and reproductive performance (Saleh *et al.,* 2011). Additionally, it reduces stress and protects cells such as mammary gland cells from lipid peroxidation (Ohtsuka *et al.,* 1998). These findings were ~~are~~ greatly supported by those outputted by Morsy and Abd El-Lateif (2017), Fahim *et al.* (2021), Amira M. Refaie *et al.* (2022), and Abdou *et al.* (2024). Moreover, milk yield increased gradually up to the third week of lactation and then decreased in the fourth one, as previously documented by El-Sayiad (1994), who reported that rabbits getting peak milk production in lactation during the third week.

Table 4. Impact of experimental rations on the milk intake of kits from doe rabbits.

Item	Experimental diet				SEM
	T1	T2	T3	T4	
Milk yield (g/d) at:					
1st week	93.7^{b}	117.0^{a}	113.0^{a}	117.1^{a}	3.416
2nd week	140.6^{b}	154.0^{a}	151.2^{ab}	158.3^{a}	4.151
3rd week	177.5^{c}	211.3^{a}	197.7^{b}	217.3^{a}	4.475
4th week	106.9^{b}	119.9^{ab}	115.5^{ab}	122.3^{a}	5.038
Average milk yield (g/d)	129.7^{c}	150.6^{a}	144.3^{b}	153.7^{a}	1.591

SEM = Standard error of means a, b, and c, : Means in the same row with different superscripts are significantly different (P<0.05)

T1: control group; T2: 1 g of SP/h/d; T3: 1g of LY/d/h; T4:0.5 g of BS/h/d.

Reproductive performance:

Data in Table 5 showed that there were no significant differences in the conception rate. The same significant results were found with litter size at birth. Meantime, mostly dietary supplementation groups had enhanced the size and weight of litter (p<0.05) than those of the control one, over at weaning. Treated groups T2, T3, and T4 showed that increased litter size by 25.42, 10.17, and 27.12% and increased litter weight by 26.64, 10.98, and 29.56%, respectively, compared to those of control group (T1).

The beneficial effect of SP on most reproductive parameters of doe rabbits can be linked to its high content of natural antioxidant pigments, vitamins and minerals (Abdelkhalek *et al.,* 2015; Niu *et al.,* 2017). These components have been strongly play a vital role in hormonal regulation, improving fertility, restoring antioxidant ovary status (Abadjieva *et al.,* 2011; Yener *et al.,* 2013), and immune system enhancement (Mirzaie *et al.,* 2018). The results were agreement with those found by Abd El-Hamid *et al.* (2022). Moreover, Abdou *et al.* (2024) mentioned that adding SP in doe rabbit rations increased litter size and weight at birth and weaning periods. In contrast, Iatrou *et al.* (2022) found that SP supplementation at 100 mg/kg of body weight to female mink didn't affect their litter size or weight. Also, the addition of LY and BS supplements improved productivity and reproduction of doe rabbits through several mechanisms, like competition with harmful microbes and repression of their toxic effects, which led to enhanced intestinal and immunity functions (Elghandour *et al.,* 2019; Abdel-Wareth *et al.,* 2021). In this respect, the data were agree with those of Morsy and Abd El-Lateif (20 17), Dimova *et al.* (2017), and Fahim *et al.* (2021), which have emphasized an increases in litter size at birth or weaning period. Recently, Amira M. Refaie *et al.* (2022) recommended that adding probiotics or higher levels of *Aspergillus awamori* led to increases in the size and weight of litter at the weaning phase.

On the other hand, the daily gain of kids in probiotic groups was significantly (p<0.001) higher than that of control group, being 108.50, 139.92, 121.89, and 143.90 for the T1, T2, T3, and T4 groups, respectively. As reported by Pascual *et al.* (1996), there is a strong relationship between milk yield and improved birth litter size and health. These results were aligned with those recognized by kritas *et al.* (2008), Kadja *et al.* (2021), and El-Deep *et al.* (2021). Similarly, Abdou *et al.* (2024) observed that rabbits feeding on SP rations had improved the daily gain of their offspring at weaning. Conversely, Seyidoglu and Galip (2014) noted that the body weight of rabbits was not affected by adding 3g of SC or 5% of SP or their mixture in their rations.

Table 5 reveals that feed conversion rate as gm feed /litter size weight weaning was significantly (P<0.05) improved with SP and BS groups than that of LY and control one over 1-21 days of lactation. While, feed conversion rate for all tested rations was significant (P<0.05) improved than that of the control one (T1), during the period from 22 to 30 days of lactation. Results appeared to a harmony with those obtained by Sikiru *et al.* (2019), Wang *et al.* (2020), El-Deep *et al.* (2021), Kadja *et al.* (2021), and Abdou *et al.* (2024) when probiotics were added alone or in a mixture form. Also, Abbdel-Wareth *et al.* (2021) reported that rabbits received higher levels of mixed probiotics combined fenugreek could be enhanced gut health and growth performance as well as improved feed conversion. However, Lugar`a *et al.* (2022) reported that adding spirulina to the high-energy diets for sows didn't affect feed intake or FCR through the gestation and lactation periods. Also, Fathi *et al.* (2017) reported that FCR had no effect by adding two levels of BS to the diets of rabbits.

Regarding the mortality rate (MR%) measurement, dietary supplementations significantly (P<0.05) lowered the mortality rate in comparison to the control group during the first period, while during the second period from 22 to 30 days, the groups (T2 and T4) had significantly (P<0.05) decreased MR% than those in the control group. While, there was an insignificant reduction in MR% with LY group with comparison with those of control one.

Enhancing the production and reproductive performance and decreasing mortality rate with the addition of SP, which might be able to reduce oxidative stress during fertilization, because it contains essential materials such as total phenolic acids, flavonoid compounds, antioxidants and immune modulatory enhancers (Mirzaie *et al.,* 2018). Additionally, as explained by Ogawa *et al* (2001) feeding probiotics could be improved IgA released and protected against E. coli enteritis, resulting in a decreased mortality rate. Moreover, Kritas *et al.* (2008) reported that "feeding probiotics may have a growth–promoting activity by competing with harmful gut flora and stimulating the immune system''. In addition, Kimsé *et al.* (2012) explained that probiotic supplementation could be modifying the physico-chemical characteristics as an increase in the redox potential of caecum, which leads to improved digestive health. The same authors indicated that the mortality rate of growing rabbits fed S. cerevisiae rations was lowered by 22.5% compared to 45% for those fed a control ration. Furthermore, our results are consistent with those of Dimova *et al.* (2017) and Abdou *et al.* (2024) when probiotics were added to rabbit rations. Also, Belhassen *et al.* (2016) reported that yeast supplementation enhanced fertility and pup survival, as well as reducing the mortality rate of doe rabbits. Additionally, Morsy and Abd El-Lateif (2017) found that the mortality rate of pups decreased with increased mannan oligosaccharides in rabbit rations. Contrary to our results Colombino *et al.* (2022) noticed that rabbit-fed Lactobacillus acidophilus rations recorded a higher MR% compared to that of control one.

Table 5. Effect of experimental rations on the reproductive performance of doe rabbits

Item	Experimental diet				SEM
	T1	T2	T3	T4	
Conceptions rate	**70**	**80**	**80**	**80**	**5.03**
Litter size:					
At birth (alive)	7.5	8.3	7.8	8.2	0.428
At weaning (30 days)	5.9[b]	7.4[a]	6.5[ab]	7.5[a]	0.372
Mortality rate:					
Birth – 21 days	21.7[a]	8.7[b]	10.8[b]	7.3[b]	3.690
Birth – Weaning	21.33[a]	10.84[b]	16.67[ab]	8.54[b]	3.553
Litter weight (g):					
Birth	405.5	437.5	405.5	452.5	12.26
Weaning (30 days)	3660.5[c]	4635.0[a]	4062.0[b]	4742.5[a]	49.97
Daily gain of litter (g/d)	108.5[c]	139.92[a]	121.89[b]	143.9[a]	37.48
Daily feed intake (g/d) for:					
Lactating does	264.0	251.5	270.5	265.6	11.70
Kids (22-30 day)	208.6	198.7	213.7	209.9	5.830
Feed conversion ratio (g/g):					
1 to 21 days of lactation (1)	2.98[a]	2.46[b]	2.96[a]	2.57[b]	0.107
22 to 30 days of lactation (2)	3.16[a]	1.99[c]	2.52[b]	2.04[c]	0.084

SEM = Standard error of means[a, b, c, and d]: Means in the same row with different superscripts are significantly different (P<0.05).
T1: control group; T2: 1 g of SP/h/d; T3: 1g of LY/d/h; T4:0.5 g of BS/h/d. (1) As feed intake of does from 1 to 21 days (g) per litter weight gain from 1 to 21 days (g).(2) As feed intake of does from 22 to 30 days (g) per litters weight gain from 22 to 30 days (g).

Blood parameters:

Table 6 showed that the TP, AL, and GL concentrations were significantly (P<0.05) higher, while blood serum urea and creatinine levels were significantly (P<0.05) lower in the tested rations compared to those of the control one. Otherwise, no significant differences in respect of blood serum AST and ALT concentrations were observed among all experimental groups.

Blood serum TP and GL concentrations are considerably working as indicators of immune system activity, while the Al concentration in blood serum serves as indicator of liver function (Ismail *et al.* 2002; White *et al.*, 2002; Selem *et al.*, 2007). According to the studies of Wang *et al.* (2020), BS could be increased each of TP, and GL, which might be improving protein and carbohydrate metabolism (Stanley *et al.*, 2002; Oh *et al.*, 2008). Also, according to the results of Farag *et al.* (2016), the contents of TP, Al and GL were elevated with the addition of SP where such these increases might be due to its rich content of high-quality protein (all amino acid contents), phospholipids and antioxidant substances, as well as excellent minerals and vitamins. Recently, Abo Ghanima *et al.* (2020) and Kadja *et al.* (2021) found that adding probiotics and prebiotics could enhance nutrient utilization and improve immune system functions by increasing globulin levels (Terciolo *et al.*, 2019). These results are in harmony with those obtained by Seyidoglu and Galip (2014), Fahim *et al.* (2021), and Kadja *et al.* (2021). Furthermore, Helal *et al.* (2021) noticed that adding LY, SP, or their mixture in rabbit rations significantly raised TP, Al, and GL levels in comparison to the control one. Abdou *et al.* (2024) also mentioned that increasing SP levels in rabbit rations improved TP and Al levels and lowered Gl levels. In contrast, Beshara *et al.* (2018) reported that the addition of probiotics had lowered TP and Gl levels. On the other hand, all additive groups lowered blood serum creatinine and urea levels than those of control group, in order to it may have enhanced protein metabolism and improved kidney functions. Likewise, Mahmoud *et al.* (2017) and Abdou *et al.* (2024) noticed that similar findings in rabbits that were fed probiotic rations. In contrast, Seyidoglu and Galip (2014), Fahim *et al.* (2021), and Kadja *et al.* (2021) reported that the addition of probiotics to rations of rabbits didn't affect blood urea, or creatinine concentrations. Moreover, probiotic supplementation didn't affect blood serum ALT and AST levels, indicating these additives didn't negatively influence liver function and such findings are in line with those found by Seyidoglu and Galip (2014), Abdelhady and El-Abasy (2015) and Helal *et al.* (2021). Also, Abdou *et al.* (2024) observed that adding SP at high levels in rabbit rations didn't affect blood serum AST levels and decreased ALT levels significantly (P<0.05). Moreover, Belhassen *et al.* (2016) didn't find any effects on blood parameters when yeast was added to rabbit rations. Similarly, Hassanein *et al.* (2014) had observed like these results when added some algae species to rabbit rations.

Table 6. Blood serum constituents of doe rabbits fed the experimental diets.

Item	T1	T2	T3	T4	SEM
Total protein (g/dl)	6.16[c]	7.22[a]	6.86[b]	7.12[a]	0.19
Albumin (g/dl)	3.13[c]	4.58[a]	4.42[a]	4.50[a]	0.13
Globulin (g/dl)	3.03[a]	2.64[b]	2.44[c]	2.62[b]	0.25
Creatinine (mg/dl)	1.19[a]	0.97[b]	1.00[b]	0.98[b]	0.05
Urea (mg/dl)	16.26[a]	12.34[b]	12.96[b]	13.01[b]	1.53
AST (IU/l)	22.51	22.05	20.47	17.24	0.4
ALT (IU/l)	25.41	23.34	22.16	19.41	4.62

SEM = Standard error of means[a, b and c] : Means in the same raw with different superscripts are significantly (p<0.05) difference.
T1: control group; T2: 1 g of SP/h/d; T3: 1g of LY/d/h; T4:0.5 g of BS/h/d.

Economic feed efficiency:

The results presented in Table 7 revealed that although doe rabbits fed probiotic rations had higher total feed costs compared to the control, they showed the best values economically compared with the control.

Table 7. Impact of probiotic supplementation on the economic efficiency of doe rabbit production.

Item	Experimental diets			
	T1	T2	T3	T4
Feed cost of doe (L.E.)	117.66	112.38	121.01	117.21
Additive cost of doe (L.E.)	0.00	18.00	2.40	3.00
Total feed cost of doe (L.E.)	117.66	130.38	123.40	120.21
Selling price of kids per doe (L.E.)[1]	146.42	185.40	162.48	189.72
Economic feed efficiency (%)[2]	124	142	132	158
Economic efficiency relative to control (%)[3]	100.00	114.52	106.45	127.42

T1: control group; T2: 1 g of SP/h/d; T3: 1g of LY/d/h; T4:0.5 g of BS/h/d.- Other conditions like mortality (%) and management are fixed. - Price (L.E. per kg) at 2021 was: 8.78 PD; 300 SP; 40 LY; 100 BS.1 Price of kg live body weight was 40 L.E.2 Economic efficiencies = (selling price/ total feed cost) x100.3 Economic efficiency relative to control, % = (economic efficiency of T2, T3 and T4 x 100/ economic efficiency of T1) x100.

Generally, doe rabbits fed T4 showed the highest economic feed efficiency followed by T2 and T3, but those fed the control diet showed the lowest values. Data were comparable with those found by Abdou *et al.* (2024) when adding SP in rabbit rations. Also, Fahim *et al.* (2021) noticed that the inclusion of Biogen with two levels in the rabbit rations improved economic efficiency compared to the unsupplemented ration. Moreover, Abd El-Aziz *et al.* (2021) stated that the best economic efficiency obtained when yeast was added to the rations of rabbits as growth promoter. Accordingly, to the results of Kalma *et al.* (2018), where they were added SC and *lactobacillus sporogenes* at

0.5g/kg feed and therefore such treatment was enhanced profitability of rabbit's production. Furthermore, under heat stress, Morsy and Abd El-Lateif (2017) found that the highest economic efficiency was recorded with increasing mannan oligosaccharides at levels up to 1.5 g in the diets of rabbit does.

CONCLUSION

In the present study, adding *spirulina* or *Bacillus subtilis* to rabbit rations can be a positive strategy for enhancing productive and reproductive performance and health status, of doe rabbits and also improving the daily gains and economic efficiency of their offspring.

REFERENCES

Abadjieva, D.; K. Shumkov; E. Kistanova; D. Kcheva; and B. Georgiev (2011). Opportunities for the improvement of the reproductive performances in female animals. Biotechnology in Animal Husbandry 27(3):365–372. doi: 10.2298/BAH1103365A. [CrossRef] [Google Scholar]

Abd El-Aziz, A.H.; K. M.Mahrose; N.I. El-Kasrawy and A.E.W.A. Alsenosy (2021). Yeast as growth promoter in two breeds of growing rabbits with special reference to its economic implications. *Anais da academia brasileira de ciências* 93(2):1–13): e20190274. https://doi.org/10.1590/0001-3765202120190274. [Web of Science®], [Google Scholar]

Abd El-Hamid, I; W. Fouda; H. Shedeed; S. Moustafa; A. Elbaz; S. Bakr; B. Mosa; A. Morsy; A. Hasan; and K. Emam (2022). Influence of microalgae Nannochloropsis oculata on blood constituents, reproductive performance and productivity in hi-plus doe rabbits under North Sinai conditions in Egypt. *Journal of Animal Health Production* 10(2):135–45. http://dx.doi.org/ 10.17582/journal.jahp/2022/10.2.135.145

Abdelhady, D.H.; and M.A. El-Abasy (2015). Effect of Prebiotic and Probiotic on Growth, Immuno-hematological responses and Biochemical Parameters of infected rabbits with *Pasteurella multocida*. *Benha Veterinary Medical Journal*, *28*, 40–51. [Google Scholar] [CrossRef][Green Version]

Abdelkhalek, N.K.M.; E.W. Ghazy; and M.M. Abdel-Daim (2015). Pharmacodynamic interaction of Spirulina platensis and deltamethrin in freshwater fish Nile tilapia, Oreochromisniloticus: Impact on lipid peroxidation and oxidative stress. *Environmental Science and Pollution Research*, 22(4): 3023-3031. doi: 10.1007/s11356-014-3578-0

Abdel-Wareth, A.A.A.; F.S.O. Elkhateeb; Z.S.H. Ismail; A.A. Ghazalah; & J. Lohakare (2021). Combined effects of fenugreek seeds and probiotics on growth performance, nutrient digestibility, carcass criteria, and serum hormones in growing rabbits. *Livestock Science*, *251*, 104616. doi:10.1016/ j.livsci.2021.104616 [Google Scholar] [CrossRef]

Abdou, A.A.; S.M. Raafat; G. E. Younan; M. E. Farag; W.M. Abd El-Wahab, G. F. Shahin; M. M. El-Naharwy; A.R. Khattab (2024). Effect of Spirulina Algae levels supplements on the productive and reproductive performance of doe rabbits. *Egyptian Journal of Veterinary Sciences.* 2024 Dec 1; 55(7):2095-106.

Abo Ghanima, M.M.A.; A.H.A. El-Aziz; A.E. Noreldin; M.S. Atta; S. A. Mousa; and A.H. El-Far (2020). β-glucan administration improves growth performance and gut health in New Zealand White and APRI rabbits with different ββ breed responses. *Plos one*, *15*(6), p.e 0234076.

Amer, F.; H. Amin; W. Ali; T. El-Aasar; and A.B. Azoz (2016). Effect of dietary addition of zinc enriched spirulina on growth and physiological performance in growing rabbits. *Egyptian Journal of Rabbit Sciences*, 26(2), 155-173. doi: 10.21608/ ejrs.2016.42067 28.

Amira M. Refaie, Manal S. Mohamed; Enayat H. Abo El-Azayem and Sherein H. Mohamed (2022). Productive Performance of Doe Rabbits to Dietary Supplementation of Aspergillus awamori. *Advances in Animal and Veterinary Science*, 10(5): 1023-1030.

AOAC. (2005). International Official methods of analysis of AOAC. Arlington, TX: AOAC International. [Google Scholar]

Ayyat, M.S.; A.A. Al-Sagheer; K.M., Abd El-Latif; and B.A. Khalil (2018). Organic selenium, probiotics, and prebiotics effects on growth, blood biochemistry, and carcass traits of growing rabbits during summer and winter seasons. *Biological trace element research*, Nov; 186:162-73.

Belhassen, T.; E. Simon; A. Potel; E. Auclair; and R. Bergaoui (2016). 'Effect of diet supplementation with live yeast (saccharomyces cerevisiae) on performance of rabbit does and their progenies'. *World Rabbit Science, 24: 77-82* 24 (May 2015): 77–82. https://doi.org/10.4995/wrs.2016.3917.

Beshara, M.; A. Alazab; H. Fahim; A. el Desoky; M. Ragab; A.E.G. el Shahat; A. El-Gamal (2018). Effect of early dietary supplementation of probiotic and feed restriction post weaning on productive and economical performance of growing rabbits. *Egyptian Journal of Rabbit Science,* 28, 195–222. [CrossRef]

Bhatt, R.S.; A.R. Agrawal and A. Sahoo (2017). Effect of probiotic supplementation on growth performance, nutrient utilization and carcass characteristics of growing Chinchilla rabbits. *Journal of Applied Animal Research,* 45(1), pp. 304-309. https:// doi.org/ 10.1080/09712119.2016.1174126

Cartman, S.T.; L.R.M. Ragione; and M.J. Woodward (2008). Bacillus subtilis spores germinate in the chicken gastrointestinal tract. Appl. environ. Microbiol., 74: 5254–5258. https://doi.org/10.1128/ AEM.00580-08

Colombino, E., I. Biasato; A. Michetti; M.G. Rubino; I. Franciosa; M. Giribaldi; S. Antoniazzi; S. Bergagna; G. Paliasso; I. Ferrocino; and L. Cavallarin (2022). Effects of dietary supplementation of Lactobacillus acidophilus on blood parameters and gut health of rabbits. *Animals*, *12*(24), p.3543.

De Blas, J.C.; and G.G. Mateos (1998). Feed Formulation. In: De Blas, C., and Wiseman J. (Eds). The Nutrition of the Rabbit, CABI Publishing. (CIA) International, Wallingford Oxon, UK, 241-253.

Dimova, N.; S. Laleva; P. Slavova; Y. Popova; M. Mihaylova; N. Pacinovski; (2017). Effect of probiotic "Zoovit" on productivity of rabbits. Macedonian. *Journal of Animal Science,* 7(1), pp.123–127. http://dx.doi.org/10.54865/mjas1771-2123d [Google Scholar]doi: 10.21608/ejrs.2014.47489Doumas, B. (1971). Colorimetric determination of albumin. *Clinica chimica acta* 258, no. 1 (1997): 21-30.

Duncan, D.B., 1955. Multiple range and multiple F-test Biometrics, 11.1.

EFSA; Panel on Biological Hazards (BIOHAZ) (2013). Scientific Opinion on the maintenance of the list of QPS biological agents intentionally added to food and feed (2013 update). Efsa Journal 11:3449. [Crossref], [Google Scholar]

El-Badawi, A.Y.; F.I.S. Helal; M.H.M. Yacout; A.A. Hassan; S. El-Naggar; E.H. Elsabaawy (2017). Growth Performance of Male NZW Rabbits Fed Diets Supplemented with Beneficial Bacteria or Live Yeast. *Agricultural Engineering International: CIGR Journal* 220–226.

El-Deep, M. H.; M.A. Dawood; M.H. Assar; and B. Ahamad Paray (2021). Aspergillus awamori positively impacts the growth performance, nutrient digestibility, antioxidative activity and immune responses of growing rabbits. *Veterinary Medicine and Science*, *7*(1), 226-235.

Elghandour, M.M.Y., Z.L.Tan; S.H. Abu Hafsa; M.J. Adegbeye; R. Greiner; E.A. Ugbogu; J.C. Monroy; and A.Z.M. Salem (2019). Saccharomyces cerevisiae as a probiotic feed additive to non and pseudo-ruminant feeding: A review. *Journal of applied microbiology, 128(3):658-74.*[Google Scholar] [CrossRef] [Green Version]

Elmasry, A.M.A., L.A. Miranda; G. Mendoza; & F.X. Plata (2021). Effect of yeast type and dose on growth performance and nutrient digestibility of growing rabbits fed maize or barley. *Indian Journal of Animal Research.* doi: 10.18805/ IJAR.B-1331.

El-Sayiad, G.H.A. (1994). Study on milk production of New Zealand White and Californian rabbits under Egyptian conditions. *Egyptian Journal of Rabbit Science,* **4**(1): 47-59.

Emmanuel, D.; A. Amaka; E. Okezie; U. Sunday; O. Ethelbert (2019). Epididymal sperm characteristics, testicular morphometric traits and growth parameters of rabbit bucks fed dietary Saccharomyces cerevisiae and/or zinc oxide. *Brazilian Journal of Poultry Science,* 21, pp.eRBCA. [CrossRef]

Fahim, H.N.; Mona A Ragab; and Soheir A Shazly (2021). Effect of using biogen as a feed additive on productive and reproductive performance of rabbits. *Journal of Animal and Poultry Production,* 12(6), pp.189-196. https://doi.org/10.21608/jappmu.2021.182674.

Farag M.R.; M. Alagawany; M.E. Abd El-Hack; and K. Dhama (2016). Nutritional and healthical aspects of Spirulina (Arthrospira) for poultry, animals and human. International *Journal of Pharmacology,* 12(1):36–51(2016). doi: 10.3923/ijp.2016.36.51. [CrossRef] [Google Scholar]

Fathi, M.; M. Abdelsalam; I. Al-Homidan; T. Ebeid; M. El-Zarei; and O. Abou-Emera (2017). Effect of probiotic supplementation and genotype on growth performance, carcass traits, hematological parameters and immunity of growing rabbits under hot environmental conditions. *Animal Science Journal*, 88(10), 1644-1650. https://doi.org/10.1111/asj.12811. [CrossRef]

Gomaa, A.S.; A.E. Kholif; A.M. Kholif; R. Salama; and H.A. El-Alamy (2018). Sunflower oil and Nannochloropsis oculata microalgae as sources of unsaturated fatty acids for mitigation of methane production and enhancing diets' nutritive value. *Journal of Agricultural and Food Chemistry* 66(8), 1751–1759. [CrossRef]

Gu, S.B.; L. Zhao; Y. Wu; S.C. Li; J.R. Sun; J.F. Huang; and D.D. Li (2015). Potential probiotic attributes of a new strain of Bacillus coagulans CGMCC 9951 isolated from healthy piglet feces. World Journal of Microbiology and Biotechnology. 31: 851–863. https://doi. org/10.1007/s11274-015-1838-x

Guo, M.; F. Wu; G. Hao; Q. Qi; R. Li; N. Li; L. Wei; and T. Chai (2017). Bacillus subtilis improves immunity and disease resistance in rabbits. *Frontiers in immunology*, 8:354. doi: 10.3389/fimmu.2017.00354

Hassanein, A.M.; M.M. Arafa; M.A. Abo Warda; A. Abd–Elall, (2014). Effect of using Spirulina platensis and chlorella vulgaris as feed additives on growing rabbit performance. *Egyptian Journal of Rabbit Science*, 413-431.

Helal, F.; A. El-Badawi; S. El-Naggar; M. Shourrap; O. Aboelazab; S. Abu Hafsa. (2021). Probiotics role of Saccharomyces cerevisiae and Bacillus subtilis in improving the health status of rabbits' gastrointestinal tract. *Bulletin of the National Research Centre.* pp. 45:66. https://doi.org/10.1186/s42269-021-00522-0

Henry, R.J. (1974) Clinical chemistry, principles and technics. Harper and Row, New York, p 407

http://dx.doi.org/10.17582/journal.aavs/2022/10.5.1023.1030

https://doi.org/10.1371/journal.pone.0234076.

Hu, S.L.; X.F. Cao; Y.P. Wu; X.Q. Mei; H. Xu; Y. Wang; X.P. Zhang; G. Li; and W.F. Li (2018). Effects of probiotic Bacillus as an alternative of antibiotics on digestive enzymes activity and intestinal integrity of piglets. *Frontiers in microbiology*,9:2427.https:// doi.org/10.3389/fmicb .2018.02427

Iatrou A.M.; G.A. Papadopoulos; I. Giannenas; A. Lymberopoulos; and P. Fortomaris (2022). Effects of Dietary Inclusion of Spirulina platensis on the Reproductive Performance of Female Mink. *Veterinary Science,* 9(8), 428. https:// doi.org/10.3390/vetsci9080428

Ismail, A.M.; M.A. Abou-El-Ellaa; and A.A. Sedki (2002). Blood metabolites, growth and reproductive performance and immune responsiveness in growing and doe rabbits a affected by Acitrol treatments. *Egyptian Journal of Agricultural Research,* 80(4):1789-808.

Kadja, L.; A.L. Dib; N. Lakhdara; A. Bouaziz; E. Espigares; and M. Gagaoua (2021). Influence of three probiotics strains, lactobacillus rhamnosus GG, Bifidobacterium animalis subsp. lactis BB-12 and Saccharomyces boulardii CNCM I-745 on the biochemical and Haematological profiles and body weight of healthy rabbits. *Biology*, *10*(11), p.1194.

Kalma, R.P.; H.D. Chauhan; A.K. Srivastava; and M.M. Pawar (2018). Growth and blood profile of broiler rabbits on probiotic supplementation. *Indian Journal Small Ruminants* 24: 66-69.

Kholif, A.E.; T.A. Morsy; O.H. Matloup; U.Y. Anele; A.G. Mohamed; and A.B. El-Sayed (2017). Dietary Chlorella vulgaris microalgae improves feed utilization, milk production and concentrations of conjugated linoleic acids in the milk of Damascus goats. *The Journal of Agricultural Science,* 155, 508–518. https://doi.org/10.1017/S0021 859616000824

Kiczorowska, B.; W. Samolińska; A.R.M. Al-Yasiry; P. Kiczorowski and A. Winiarska-Mieczan (2017). The natural feed additives as immunostimulants in monogastric animal nutrition–a review. *Annals of Animal Science,* 17(3), 605–25, https://doi.org/10.1515/aoas-2016-0076, 2-s2.0-85027141413. [CAS] [Web of Science®] [Google Scholar]

Kimsé, M., C. Bayourthe; V. Monteils; L. Fortun-Lamothe; L. Cauquil; S. Combes; and T. Gidenne (2012). Live yeast stability in rabbit digestive tract: consequences on the caecal ecosystem, digestion, growth and digestive health. *Animal feed Science and Technology*, 173(3-4):235-43.doi: 10.1016/j.anifeedsci.2012.01.012. [CrossRef] [Goo gle Scholar]

Komoto, T.T.; T.M. Bernardes; T.B. Mesquita; L.F.B. Bortolotto; G. Silva; T.A. Bitencourt; S.J. Baek; M. Marins, M.; and A.L. Fachin (2018). Chalcones repressed the AURKA and MDR proteins involved in metastasis and multiple drug resistance in breast cancer cell lines. *Molecules,* 23. https://doi.org/10.3390/molecules23082018

Krieg, R.; W. Vahjen; W. Awad; M. Sysel; S. Kroeger; E. Zocher; H.W. Hulan; G. Arndt; J. Zente.k (2010) Performance, digestive disorders and the intestinal microbiota in weaning rabbits are affected by an herbal feed additive. *World Rabbit Science* 17(2):87-95. [CrossRef]

Kritas, S.K.; E.I. Petridou; P. Fortomaris; E. Tzika; G. Arsenos and G. Koptopoulos (2008). The effect of probiotics on microbiology, health and performance of fattening rabbits. *Asian- Australasian Journal of Animal Sciences*, 21(9):1312–1317. [Crossref] [Web of Science ®], [Google Scholar]

Liu, X.; W. Zhao; D. Yu; J.G. Cheng; Y. Luo; Y. Wang; Z.X. Yang; X.P. Yao; S.S. Wu; W.Y. Wang; and W. Yang (2019). Effects of Compound Probiotics on the Weight, Immunity Performance and Fecal Microbiota of Forest Musk Deer. *Scientific Reports* 9(1):19146. doi: 10.1038/s41598-019-55731-5. [PMC free article] [PubMed] [Cross Ref] [Google Scholar]

Lugar`a, R.; L. Realini; M. Kreuzer; and K. Giller (2022). Effects of maternal high-energy diet and spirulina supplementation in pregnant and lactating sows on performance, quality of carcass and meat, and its fatty acid profile in male and female offspring. *Meat Science,* 187–108769. https://doi.org/10.1016/ j.meatsci.2022.108769

Machida, M.; K. Asai; M. Sano; T. Tanaka; T. Kumagai; G. Terai; K.I Kusumoto; T. Arima; O. Akita; Y. Kashiwagi; and K. Abe (2005). Genome sequencing and analysis of Aspergillus oryzae. *Nature,* 22:438(7071), pp.1157-1161. https://doi.org/10.1038/natur e04300M

Mahmoud A.E.; M.M. Naguib; A.M. Higazy; and Y.Y. Sultan (2017). Effect of substitution soybean by blue green alga Spirulina Platensis on performance and meat quality of growing rabbits. *American Journal of Food Technology,* Vol. 12 (1), 51-59. https://scialert.net/abstract/ ?doi=ajft.2017.51.59

Makarenko; M.S.; V.A. Chistyakov; A.V. Usatov; M.S Mazanko; E.V. Prazdnova; A.B. Bren; I.F. Gorlov; Z.B. Komarova; and M.L. Chikindas; (2019). The impact of Bacillus subtilis KATMIRA1933 supplementation on telomere length and mitochondrial DNA damage of laying hens. *Probiotics and antimicrobial proteins.* 11(2): 588–593, https://doi.org/10.1007/s12602-018-9440-9, 2-s2.0-85049577621. [CAS] [PubMed] [Web of Science®] [Google Scholar]

Marquez-Rocha, F.J.; N. Nishio; S. Nagai; and K. Sasaki (1995). Enhancement of biomass and pigment production during growth of Spirulina platensis in mixotrophic culture. *Journal of Chemical Technology & Biotechnology*: International Research in Process, Environmental AND Clean Technology. 1995 Feb;62(2):159-64.

Mirzaie, S.; F. Zirak-Khattab; S.A. Hosseini; and H. Donyaei- Darian (2018). Effects of dietary Spirulina on antioxidant status, lipid profile, immune response and performance characteristics of broiler chickens reared under high ambient temperature. *Asian- Australasian Journal of Animal Sciences,* 31: 556-563. doi: 10.5713/ajas.17.0483

Morsy, W.A.; and A.I. Abd El-Lateif (2017). Effect of supplemental mannan oligosaccharide to rabbit diets on productive and reproductive performance of does during summer season in egypt. *Egyptian Journal Nutritrition and Feeds,* 20 (2) Special Issue: 255- 264. https://doi.org/10.21608/ejnf.2017.104134

Niu, Y.J.; W. Zhou; J. Guo; Z.W. Nie; K.T. Shin; N.H. Kim; W.F. LV and C.C.X. Cui (2017). Phycocyanin protects against mitochondrial dysfunction and oxidative stress in parthenogenetic porcine embryos. *Scientific Reports* 7:1–10. https://doi.org/10.1038/s41598-017-17287-0

NRC (1977). National Research Council Nutrients requirements of rabbits, National Academy of Science, Washington, DC, USA.

Ogawa, M.; K. Shimizu; K. Nomoto; M. Takahashi; M. Watanuki; R. Tanaka; T. Tanaka; T. Hamabata; S. Yamasaki; and Y. Takeda (2001). Protective effect of Lactobacillus casei strain Shirota on Shiga toxin- producing Escherichia coli O157:H7 infection in infant rabbits. *Infection and immunity*, 69, 1101–1108.

Oh, Y.K.; J.H. Kim; K.H., Kim; C.W. Choi; S.W. Kang; I.S. Nam; D.H. Kim; M.K. Song; C.W. Kim and K.K. Park (2008). Effects of level and degradability of dietary protein on ruminal fermentation and concentrations of soluble non-ammonia nitrogen in ruminal and omasal digesta of hanwoo steers. *Asian- Australasian Journal of Animal Sciences,* 21:392–403. https://doi.org/10. 5713/ajas.2008.70342

Ohtsuka, A.; T. Ohtani; and K. Hayashi (1998). Vitamin E reduces glueocorticoid-induced growth inhibition and lipid peroxidation in rats. *Journal of nutritional science and vitaminology*, 44(2):237-47. Https://doi.org/ 10.3177 /jnsv.44.237

Pascual, J.J.; C. Cervera; E. Blas; and J. Fernandez-Carmona (1996). Milk yield and composition in rabbit does using high fat diets. 6th World rabbit Congress 1996 Jul 9 (pp. 9-12). *Association Française de Cuniculture Toulouse, France.*Volume 1:259-262.

Phuoc, T.L; and U. Jamikorn (2017). Effects of probiotic supplement (bacillus subtilis and lactobacillus acidophilus) on feed efficiency, growth performance, and microbial population of weaning rabbits. *Asian- Australasian Journal of Animal Sciences,* 30, 198–205. [PubMed] [Web of Science] [Google Scholar]

Rawski, M.; B. Kierończyk; J. Długosz; S. Świątkiewicz; and D. Józefiak (2016). Dietary probiotics affect gastrointestinal microbiota, histological structure and shell mineralization in turtles. *PLoS One,* 11(2), p.e0147859.https://doi.org/10.1371/journal.pone.0147859.

Reitman, S.; and S. Frankel (1957) A colorimetric method for the determination of serum glutamic oxalacetic and glutamic pyruvic transaminases. *American Journal of Clinical Pathology*, 28(1):56-63. https ://doi.org/10.1093/ajcp/28.1.56

Ribeiroa, D.M.; J. Bandarrinhaa; P. Nannib; S.P. Alvesc; C.F. Martinsa; R.J.B. Bessac; L. Falcão-e-Cunhaa; and A.M. Almeida (2020). The effect of Nannochloropsisoceanica feed inclusion on rabbit muscle proteome. *Journal of Proteomics, 222: 103783*. doi: 10.1016/j.jprot.2020.103783

Saleh, A.A.; Y.Z. Eid; T.A. Ebeid; T. Kamizono; A. Ohtsuka; and K. Hayashi (2011). Effects of feeding Aspergillus awamori and Aspergillus niger on growth performance and meat quality in broiler chickens. *Journal Poultry Science*, 48: 201-206.

Sanders, M.E.; L. Morelli; and T.A. Tompkins (2003). Sporeformers as human probiotics: Bacillus, Sporolactobacillus, and Brevibacillus. *Comprehensive reviews in food science and food safety,* 2(3):101-10. doi:10.1111/j.1541-4337.2003.tb00017.x

SAS Institute, (2003). SAS User's Guide: Statistics. Version 8.2, SAS Institute Inc., Cary, NC.

Selem, T.S.T.; H. Ibrahim; A.M. Ali; A.M. AbdEl-Motaal and A.E.B. Zeidan (2007). Rabbit performance as affected by OriganumMajorana in diets. The 5th Inter. Conf. On Rabbit Production in Hot Climates Hurghada, Egypt ,495 - 508.

Seyidoğlu, N. and N. Galip (2014). Effects of Saccharomyces cerevisiae and Spirulina platensis on growth performances and biochemical parameters in rabbits. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi,* 20(3): 331-336.

Sharawy, Z.Z.; M. Ashour; E. Abbas; O. Ashry; M. Helal; and H. Nazmi (2020). Effects of dietary marine microalgae, Tetraselmissuecica, on production, gene expression, protein markers and bacterial count of Pacific white shrimp Litopenaeusvannamei. *Aquaculture Research,* 51:2216-28. https://doi.org/10.1111/are.14566

Sikiru, A.B.; A. Arangasamy; A Alemede; P.R. Guvvala; S.S.A Egena; J.R. Ippala; and R. Bhatt (2019). Chlorella vulgaris supplementation effects on performances, oxidative stress and antioxidant genes expression in liver and ovaries of New Zealand White rabbits. *Heliyon* 5:2470. doi: 10.1016/j.heliyon.2019.e02470

Simonová, M.P.; L. Chrastinová; and A. Lauková (2020). Effect of beneficial strain Enterococcus faecium EF9a isolated from Pannon White rabbit on growth performance and meat quality of rabbits. *Italian Journal of Animal Science* 19: 650 - 655. doi: 10.4995/wrs.2020.11189. [CrossRef] [Google Scholar]

Sokale, A.O.; A. Menconi; G.F. Mathis; B. Lumpkins; M.D. Sims; R.A. Whelan; and K. Doranalli (2019). Effect of Bacillus subtilis dsm 32315 on the intestinal structural integrity and growth performance of broiler chickens under necrotic enteritis challenge. *Poultry Science,* 98(11), 5392–5400, https://doi.org/10.3382/ps/pez368, 2-s2.0-85072943246. CAS PubMed Web of Science® Google Scholar

Stanley, C.C.; C.C. Williams; B.F. Jenny; L.M. Fernandez; H.G. Bateman Ii.; W.A. Nipper; J.C. Lovejoy; D.T. Gantt; G.E. Goodier (2002). Effects of feeding milk replace once versus twice daily on glucose metabolism in Holstein and jersey calves. *Journal Dairy Science,* 85:2335–2344. https://doi. org/10.3168/jds.S0022-0302(02)74313-0

Tag El Din, N. (2019). Effect of dry live yeast inclusion in fattening rabbit diets on productive performance and digestibility of nutrients. *Egyptian Journal of Rabbit Science,* 29, 219–233. [CrossRef]

Terciolo, C.; M. Dapoigny; and F. Andre (2019). Beneficial effects of Saccharomyces boulardii CNCM I-745 on clinical disorders associated with intestinal barrier disruption. *Clinical and experimental gastroenterology*, *12*, 67–82. https://doi.org/10.2147/CEG.S181590 [Google Scholar] [CrossRef][Green Version]

Wang, J.; X. Ni; B. Wen; Y. Zhou; L. Liu; Y. Zeng; W. Zhao; A. Khalique; P. Wang; K. Pan; Z. Yu; B. Jing; H. Liu; and D. Zeng (2020). Bacillus strains improve growth performance via enhancing digestive function and anti-disease ability in young and weaning rex rabbits. *Applied Microbiology and Biotechnology, 104*, 4493 - 4504. doi:10.1007/s00253-020-10536-9

White, L.A.; M.C. Newman, G.L., Cromwell; and M.D. Lindemann (2002). Brewers dried yeast as a source of mannan oligosaccharides for weanling pigs. *Journal Animal Science*, 80: 2619-2628.

Yener, N.A.; O. Sinanoglu; E. Ilter; A. Celik; G. Sezgin; A. Midi; U. Deveci; and F. Aksungar (2013). Effects of spirulina on cyclophosphamide-induced ovarian toxicity in rats: Biochemical and histomorphometric evaluation of the ovary. *Biochemistry Research International*, (1):764262. doi: 10.1155/2013/764262. [PMC free article] [PubMed] [CrossRef]

Zhang, W.; C. Ma; P. Xie; Q. Zhu; X. Wang; X. Yin; and X. Kong (2019). Gut microbiota of newborn piglets with intrauterine growth restriction have lower diversity and different taxonomic abundances, *Journal of Applied Microbiology*, 127(2), 354–369, https://doi.org/10.1111/jam.14304, 2-s2.0-85067338521. CAS PubMed Web of Science® Google Scholar

Zhou, M.; H. Wang; and L.I. Ze-Yang (2013). Study on resistance to stress factors of Bacillus subtilis from swine intestinal juice. *Journal of Anhui Agricultural University*, 40 (4), 519-522 doi:10.13610/j.cnki.1672-352x.2013.04.028

الآداء الإنتاجي والتناسلي للأرانب المغذاة على علائق مدعمة بالاسبيرولينا والخميرة والباسيللس ستليس كإضافات طبيعية

على أحمد عبده ، شامه حسنى أحمد مرسى و محمد رفاعى محمود مصطفى

معهد بحوث الإنتاج الحيوانى- – مركز البحوث الزراعية – الدقى – الجيزة –مصر

الملخص

تم تصميم هذه الدراسة للتعرف على تأثير إضافة اسبيرولينا بلاتنسيس والخميرة الحية والباسيللس سابتيليس على هضم العناصر الغذائية والأداء الإنتاجي والتناسلي لأمهات ا الأرانب. تم تقسيم أربعين من إناث الأرانب يبلغ عمرهم ثمانية أشهر ووزن 5±3223 جم إلى أربع مجموعات تجريبية مماثلة وفقًا لوزن الجسم الحي. تم تغذية الأرانب على العليقة الكنترول الخالية من البروبيوتيك (كمجموعة تحكم ,T1) ، وتم تغذية المجموعات T2 و T3 و T4 على نفس النظام الغذائي مع إضافة 1 جرام من الاسبيرولينا و 1 جرام من الخميرة الحية و 0.5 جرام من الباسيلس ستيلس إلى العلف المقدم لكل أم يوميا، على التوالي. أشارت النتائج إلى أن إنتاج اللبن زاد بشكل ملحوظ (p <0.05) مع مكملات البروبيوتيك ولكنها لم تؤثر على كمية العلف المأكول. تحسنت قابلية هضم معظم العناصر الغذائية في مجموعة اسبيرولينا ثم مجموعة الباسيللس سابتيليس مقارن بمجموعة الكنترول. لم يتأثر وزن الجسم الحي للأمهات بإضافة البروبيوتيك، باستثناء فترة ما قبل الولادة، حيث كانت أوزان الأرانب في المجموعات T2 وT3 وT4 أعلى من المجموعة T1. وقد تحسن معظم الأداء الإنتاجي والتناسلي للأمهات بشكل ملحوظ في مجموعات البروبيوتيك. وقد أدى تناول مكملات البروبيوتيك إلى زيادة تركيزات البروتين الكلي والألبومين والجلوبيولين في الدم بشكل ملحوظ وخفضت تركيزات اليوريا والكرياتينين في الدم بشكل ملحوظ.. ونستنتج من الدراسة الحالية ان إضافة الاسبيرولينا أو والباسيللس سابتيليس إلى عليقة الأرانب مقارنة بمكملات الخميرة كان لها تأثير إيجابي على سمات الأداء الإنتاجي والتناسلى والحالة الصحية لامهات الأرانب، وكذلك تحسين معدل النمو اليومى والكفاءة الاقتصادية لنتاجها.