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أثر إضافة المكملات الغذائية البروبيوتيك مع أملاح الأحماض العضوية على الأداء التناسلي وكيمياء الدم في إناث الأرانب

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Impact of probiotic and/or organic acid salts supplementation on reproductive performance and blood biochemistry in Does rabbits

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الملخص:

تم إجراء دراسة تصميم عاملي لتقييم تأثير البروبيوتيك (Lactobacillus plantarum L) وفورمات الصوديوم على الأداء التناسلي للأمهات وأداء الصغار والمعايير البيو كيميائية لأرانب الفلاين (V-line) تم تقسيم اثنين وأربعين أرنبًا إلى ست مجموعات وتم إطعامها أنظمة غذائية مختلفة لمدة أربعة أشهر. تكونت المجموعات من: (1) النظام الغذائي الضابط، (2) النظام الغذائي مع 0.3 جرام (NF) فورمات الصوديوم، (3)النظام الغذائي مع 0.5 جرام NF، (4)النظام الغذائي مع 500 جرام (LP) اللاكتوباسيلس، (5)النظام الغذائي مع 500 جرام LP و0.3 جرامNF ، و(6) النظام الغذائي مع 500 جرام LP و0.5 جرام NF. تم تحليل بيانات الوزن، واستهلاك العلف، وإنتاج الحليب، وحجم القمامة، ووزن القمامة، والمعايير الكيميائية الحيوية للدم باستخدام تصميم عاملي 2×3. و**أظهرت نتائج الدراسة** أن وزن الجسم لم يتغير بشكل كبير عند إضافة البروبيوتيك والفورمات الصوديوم إلى اعلاف الامهات، سواء بمفردهما أو معًا، مقارنةً بمجموعة التحكم. إضافة 500 جرام من LP بمفرده مع 0.3% أو 0.5% من NF حسنت بشكل كبير من تناول العلف خلال الأيام 24-28 من الرضاعة. ($P<0.05$) إضافة 0.0%، 0.3%، أو 0.5 NF %إلى العلف مع 500 جرام من LP زاد أيضًا من تناول العلف مقارنة بالأعلاف غير المضافة في الأرانب. الأرانب التي تناولت اعلاف تحتوي على 0.3% و0.5% من NF أظهرت إنتاجية حليب أعلى بشكل ملحوظ خلال فترة الرضاعة مقارنة بمجموعة التحكم. أدى إضافة 0.3% و0.5% من NF إلى الأنظمة الغذائية الخالية من LP إلى أكبر زيادة في إنتاج الحليب. أدت الأنظمة الغذائية بمستويات مختلفة منNF ، مع أو بدون إضافة LP ، إلى زيادة أوزان الصغار مقارنة بمجموعة التحكم السلبية خلال فترات الرضاعة. إطعام علاف تحتوي على 500 جرام من LP خلال فترات التزاوج وما قبل أو ما بعد الولادة زاد بشكل كبير من مستويات البروتين الكلي والألبومين في التحليل الكيميائي الحيوي للدم. وجدت الدراسة أن إضافة 0.3% من الفورمات الصوديوم أدت إلى زيادة مستويات البروتين الكلي خلال فترات التزاوج وما قبل الولادة وما بعد الولادة. بالإضافة إلى ذلك، كان هناك زيادة ملحوظة في تركيز الجلوبولين مقارنة بمجموعة التحكم التي لم تحتوى على مكملات الفورمات الصوديوم. كانت مستويات الكوليسترول والجلوكوز في مصل الدم أعلى بشكل ملحوظ في إناث الأرانب التي تناولت حميات تحتوي على 500 جرام من LP عند التزاوج وخلال فترة ما قبل أو ما بعد الولادة مقارنة بالمجموعة الضابطة. ومع ذلك، أدى إضافة 500 جرام من LP إلى حميات الأرانب إلى انخفاض كبير في مستويات الدهون الثلاثية في مصل الدم مقارنة بمجموعة التحكم. أشارت النتائج إلى أن مستوى منخفض (0.3%) من مكملات الفورمات الصوديوم كان له تأثير كبير على مستويات الكوليسترول في مصل الدم.

الكلمات المفتاحية: البروبيوتيك، أملاح الأحماض العضوية، الأداء التناسلي، إناث الأرانب.

Abstract:

A factorial design study was conducted to evaluate the impact of probiotic (Lactobacillus plantarum L) and sodium formate on the reproductive performance of does, kits performance, and biochemical parameters of V-line rabbits.

Forty-two doe rabbits were divided into six groups and fed different diets for four months. The groups consisted of: (1) control diet, (2) diet with 0.3g NF, (3) diet with 0.5g NF, (4) diet with 500g LP, (5) diet with 500g LP and 0.3g NF, and (6) diet with 500g LP and 0.5g NF. Data on body weight, feed intake, milk yield, litter size, litter weight, and blood biochemical parameters were analyzed using a 2x3 factorial design.

The study results showed that body weight did not significantly change when probiotics and sodium formate were added to the diets, either alone or in combination, compared to the control group. Adding 500g LP alone with either 0.3% or 0.5% NF significantly improved feed intake during days 24-28 of lactation ($P<0.05$). Supplementing diets with 0.0%, 0.3%, or 0.5% NF along with 500g LP also increased feed intake compared to the unsupplemented diet in rabbits. Rabbits fed diets containing 0.3% and 0.5% NF showed significantly higher milk yield during lactation compared to the control group. The addition of 0.3% and 0.5% NF to LP-free diets resulted in the greatest increase in milk yield. Diets with varying levels of NF, with or without LP supplementation, led to higher litter weights compared to the negative control group throughout the nursing periods. Feeding 500g LP diets during mating and pre or post-partum periods significantly increased total protein and albumin levels in blood biochemical analysis. The study found that adding 0.3% sodium formate led to higher total protein levels during mating, pre-partum, and post-partum periods. Additionally, there was a notable increase in globulin concentration compared to the control group without sodium formate supplementation. The serum blood cholesterol and glucose levels were significantly higher in does rabbits fed diets containing 500g LP at mating and during pre- or post-partum compared to the control group. However, adding 500g LP to rabbit diets resulted in a significant reduction in serum blood triglycerides compared to the control group. The results indicated that a low level (0.3%) of sodium formate supplementation had a significant effect on serum cholesterol levels.

Key words: probiotic, organic acid salts, Reproductive performance, Female rabbit

Introduction

The majority of EU member states have approved the use of organic acids and their salts as feed additives in animal production, and they are widely regarded as safe. Organic acids, or acidifiers, have been increasingly used in non-monogastric animal diets as a substitute for antibiotics. They improve growth performance and prevent diseases by enhancing gut health, promoting beneficial bacterial growth, and increasing nutrient digestibility. Acidifiers also exhibit antimicrobial activity by controlling gut bacteria populations, enhancing proteolytic enzyme activity, and inhibiting pathogenic bacteria growth, (Papatsiros and Christodoulopoulos 2011). Diet acidification with organic acids can diminish pathogen colonization, toxic metabolite production, and improve nutrient digestibility. These acids also serve as substrates in intermediary metabolism (Fallah and Rezaei, 2013).

The lowest No Observed Adverse Effect Level (NOAEL) for maternal and embryo/ fetotoxicity in rabbits was 34 mg/kg body weight. The FEEDAP Panel found no expected adverse effects when using formic acid and sodium formate at the proposed maximum levels in complete feed for all animal species, (Efsa FeedAP Panel 2015).

It was hypothesized that the combination of chelating compounds from organic salts and probiotic effects of (Lactobacillus plantarum L) could prevent the growth of pathogenic bacteria, particularly in weaned rabbits, reducing the risk of diarrhea and high mortality rates. The demand for additives to improve rabbit production and combat infections is increasing. Using probiotics and organic salts as preventive measures against pathogens can be a valuable tool in rabbit production, reducing the need for antibiotics and benefiting the industry. Bolivar *et al.* (2018) found that combining probiotics with organic salts can have a synergistic effect in suppressing aquaculture bacterial pathogens.

The purpose of the present research is to look at how rabbit productivity is affected by the probiotics Lactobacillus plantarum (LP) and sodium formate (SF) in their meals.

1. MATERIALS AND METHODS

The experimental research was conducted at the Rabbitry Research Laboratory at the Borg El-Arab Animal Production Research Station, which is part of the Animal Production Research Institute at the Agricultural Research Center in Dokki, Egypt. The study took place from November 2023 to April 2024.

The research aimed to assess the impact of supplementing rabbit diets with varying levels of *Lactobacillus plantarum L* (LP) and Na-Formate (NF) in two trials. This combination of probiotics and organic salts in rabbit diets is a relatively new area of investigation.

Therefore, the primary objectives of this study were to evaluate the effects of adding probiotic as *(LP)* and (NF) on the reproductive performance of does, Kits performance, and the biochemical parameters of V-line rabbits.

Lactobacillus plantarum L and organic acid salts as Na-Formate material:

The Probiotic Lactobacillus plantarum factory strain utilized in this study was provided by the Egyptian Company for Medical Veterinary in Alexandria, Egypt. Sodium Formate, a medication produced and supplied by Care Pharma Groups, contains 100 gm of Sodium Formate per 1ml.

Experimental treatments and nutrition:

The tested materials of probiotic (***LP***) and organic salts (**NF**) were conducted in separate trails on Does V-line rabbits as feed additives in six experiment treat groups as follow:

1) Control diet (LP 0.0) + (NF 0.0).
2) Control diet + 0.3% (NF).
3) Control diet + 0.5% (NF).
4) Control diet + 500g (LP) + (NF 0.0)
5) Control diet + 500g LP + 0.3% NF.
6) Control diet + 500g LP + 0.5% NF.

The basal diet was prepared and pelleted to fulfill the nutritional needs of rabbits as per NRC (1977) guidelines. Rabbits had free access to the diet. The composition and nutritional content of the pelleted diet are detailed in Table 1.

Table 1: The ingredients of the experimental rations used through the growing and reproductive periods of the study.

Ingredients	Does rabbits
Berseem hay	28.00
Berley	10.30
Corn yellow	17.90
Wheat bran	12.00
Soybean meal 44%	27.00
Molasses	3.000
Di-Ca-Ph	1.000
Salt	0.300
Vit-min permix	0.300
Lysine	0.100
Methionine	0.100
Total	100.0

A total of forty-two V-line does aged 6-7 months and evaluating 3150-3250 kg were divided equally into 6 experimental clusters, with 7 does in each group, to investigate the response of doe rabbits and their litters. The animals were maintained under consistent environmental and management conditions and adhered to a 16:8 h light-dark cycle for the duration of the study. Does and bucks were randomly paired for mating, with each doe placed in the buck's cage for mating before being returned to its own cage. Pregnancy was confirmed by palpation 10 days after mating, and does that did not conceive were re-mated on the same day. The rabbits were kept in a building with windows, in cages on flat desks that had galvanized nests, feeders, and drinker nipples. The kits stayed with their mothers for nursing from birth until they were weaned at 28 days old. The number of offspring in a litter, the weight of the litter at birth, and the weaning process were all documented as the total weight per female rabbit.

Animal performance:

The rabbit's body weight (BW) was recorded weekly during gestation and lactation periods in three consecutive parities. The daily FI (FI) was determined by subtracting the leftover feed from the total amount provided and then recorded as grams per rabbit. Weekly FI was then calculated during gestation and lactation periods in three parities. MY (MY) was calculated on a daily basis by comparing the weight of the doe before and after suckling, which took place once each test day. The reduction in the mother's weight was used as a measure of MY. The LS (LS), LW (LW) (in grams) at birth and weaning were documented for each doe, and the pre-weaning survival rate (%) was also noted.

Blood samples were collected from both does and growing rabbits during mating. Xylol was used to enhance blood flow, and heparin was used as an anticoagulant. Half of each blood sample was centrifuged at 3,000 rpm for 15 minutes. The plasma obtained was stored at -20°C for analysis. Glucose, total protein (TP), albumin (ALB), and triglycerides (TG) in the plasma were measured using a spectrophotometer following the methods of Armstrong and Carr (1964), Doumas *et al*. (1971), and Fringes *et al*. (1972), respectively. GLO levels remained calculated by detracting ALB levels from TP levels. Total cholesterol (TCHO), LOW density lipoprotein (LDL), and high density lipoprotein (HDL) were determined according to Burstein *et al*. (1970), Wieland and Seidel (1983), and Bogin and Keller (1987), respectively. Plasma urea, AST, and ALT levels were assessed following the protocols of Fawcett and Scott (1960) and Reitman and Frankel (1975).

Statistical analysis: The data were analyzed using the General Linear Model procedure of the Statistical Analysis System (SAS, 2001). Analysis of variance with a one-way design was conducted to examine differences in treatment, sub-treatment, and interaction group at each sampling point based on the specified model:

$$Y_{ijk}=\mu+T_i+\delta_j+(T\delta)_{ij}+E_{ijk}$$

Duncan's Multiple Range Test (1955) was used to assess the major differences between the groups (Duncan, 1955).

2. RESULTS AND DISCUSSION

Changes body weights

Table 2 shows the impact of supplementing *Lactobacillus planterium L* with varying levels of Na-formate on the body weight change of female V-line rabbits. The initial body weight of the does V-line rabbits fluctuated from 3164 to 3175 g, with no significant differences among treatments, indicating a casual spreading of rabbits across the diverse treats.

Table 2: shows the live BW of does as a function of feeding meals supplemented with (NF) and/or (LP).

Treatments	Body weight (g)		
	Initial	At mating	Pre-partum
Main effect of *LP*:			
Control	3164	3244	3349
500g/Ton *Lactobacillus*	3175	3269	3407
SEM	24.77	21.23	23.59
P value	0.746	0.429	0.153
Main effect of NF supplements			
0.0 Na-formate	3165	3235	3345
0.3 Na-formate	3185	3285	3405
0.5 Na-formate	3165	3255	3385
SEM	30.65	27.61	33.09
P value	0.826	0.421	0.419
Interaction effect *LP*× NF			
P value	0.4344	0.7044	0.4838

Regardless of organic acid supplementation, incorporating *LP* 0 and 500g/Ton in rabbit diets did not expressively mark live BW at mating or pre-partum. However, female rabbits fed diets with 500g (*LP*) showed an increase in BW from mating to pre-partum, with weight gains of 0.77% and 1.73% at mating and pre-partum, respectively. These results align with the studies by Lascano and Heinrichs. (2009), which showed no significant changes in structural measurements in dairy heifers when fed a diet supplemented with yeast culture. Additionally, Maertens and Ducatelle (1996) found that adding BIOSAF *Saccharomyces cerevisiae* (SC) 47, S.I. Lesaffre, at a meditation of 10^{10} CFU/g to rabbit does did not result in significant changes in BW at 14 days post insemination (4.81 kg control vs. 4.60 kg, P>0.1), at parturition (4.66 kg control vs. 4.44 kg, P>0.1), at 3 weeks post-parturition (4.76 kg control vs. 4.70 kg, P>0.1), and at weaning (4.65 kg control vs. 4.64 kg, P>0.1).

When the effect of (*LP*) was overlooked, BW was not significantly affected by 0.3% and 0.5% NF levels at mating and pre-partum (P=0.441 and 0.449). Rabbits fed diets with 0.3% NF had slightly higher BW after mating and at pre-partum compared to those on the control diet or 0.5% NF, with no significant differences between them.

Table 2 results indicated that the interaction between Probiotic (*LP*) and organic acid salts (NF) at levels 0.3 and 0.5 was not significant in V-line female rabbits at mating and pre-partum. The group receiving 500g (*LP*) with 0.3% (NF) had the maximum BW, while the control group had the deepest weight during mating and pre-partum.

Feed Intake (FI):

The study revealed that the level of *LP* had a significant impact on FI from early pregnancy through the 14th week of lactation. A reduction in FI was observed during the 0-28 weeks of pregnancy and 0-14 weeks of lactation when rabbits were fed diets containing 500g *LP*. However, this decrease was not consistent during the 14-28 weeks of lactation, as FI during this period notably increased with the addition of 500g *LP* in the diet (P=0.45). Maertens and Ducatelle (1996) demonstrated that adding (SC) concentration of 10^{10} CFU/g to doe rabbits did not consequence in important changes in feed consumption between different treatments during pregnancy (177g control *vs* 161g, P>0.1), between parturition and 3 weeks postpartum (341g control *vs* 376g, P>0.1), while there was an increase in FI between 3 weeks and weaning (457g control *vs* 563g, P=0.02). Conversely, Nde *et al*. (2014) designated that the adding of Celmanax® (a yeast culture product) to sheep increased both roughage and total DMI (P<0.05). Furthermore, Kholif and Khorshed (2006) discovered that MY per dry matter intake significantly improved with animals supplemented with yeast.

When the impression of *LP* level was not taken into account, the effects presented that NF had a significant effect on FI during pregnancy (0-14 and 14-28 weeks) and lactation periods (0-14 weeks). Rabbits fed diets containing 0.3% and 0.5% NF consumed less feed during pregnancy (0-14 and 14-28 weeks) (503.4 and 205.3g/d vs 208.8, P=0.006) and (204.1 and 205.6g/d *vs* 208.2, P=0.004), respectively. Additionally, FI during the lactation period (0-14 weeks) for rabbits receiving 0.3% and 0.5% NF in their diets was lower (201.9 and 202.7g/d, P=0.005) compared to the control (204.2g/d). However, FI tended to increase (204.1 and 201.7g/d, P=0.004) equated to the regulator (195 g/d) during the lactation period from 14-28 weeks.

The data in Table 3 show the impact of 500g *LP* levels and different types of NF on the (FI) of doe rabbits. Adding 0.0% NF to the *LP*-free basal diet led to a significant increase in feed consumption related to the additional trial groups throughout the study, except for the 14-128 week lactation period. Additionally, the results indicate that supplementing diets containing 500g *LP* with 0.0%, 0.3%, and 0.5% NF caused in a major increase (P=0.015) in FI by 2.82%, 3.33%, and 2.78%, respectively, compared to rabbits fed the same diet without supplementation.

Table 3: FI of Does rabbits as affected by feeding diets added with (*LP*) and/ or (NF).

Treatments	FI g/d/h			
	During pregnancy		During Lactation	
	0-14	14-28	0-14	14-28
Main effect of *LP*:				
0.0 *LP*	209.5^{a}	208.9^{a}	204.6^{a}	195.0^{b}
500g *LP*	202.1^{b}	203.1^{b}	201.3^{b}	201^{a}
SEM	1.05	0.78	0.46	0.46
P value	0.001	0.041	0.0001	0.045
Main effect of NF supplements				
0.0 NF	208.8^{a}	208.2^{a}	204.2^{a}	195.^{b}
0.3 NF	205.3^{b}	205.6^{b}	202.7^{b}	201.7^{a}
0.5 NF	203.4^{b}	204.1^{b}	201.9^{b}	204.1^{a}
SEM	1.54	1.17	0.68	0.68
P value	0.006	0.004	0.005	0.004
Interaction effect *LP* × NF				
0.0 *LP* × 0.0 NF	214.8^{a}	212.9^{a}	206.9^{a}	192.5^{b}
0.0 *LP* × 0.3 NF	209.1^{ab}	208.7^{ab}	204.5^{ab}	194.5^{b}
0.0 *LP* × 0.5 NF	204.7^{ab}	205.2^{ab}	202.5^{b}	197.0^{ab}
500g *LP* × 0.0 NF	202.8^{ab}	203.6^{b}	201.6^{b}	198.1^{a}
500g *LP* × 0.3 NF	201.5^{b}	202.6^{b}	201.0^{b}	198.9^{a}
500g *LP* × 0.5 NF	202.1^{b}	203.0^{b}	201.3^{b}	198.0^{a}
SEM	1.56	1.15	0.68	0.68
P value	0.019	0.013	0.016	0.015

$^{a-b}$ different superscripts within a column indicate significant differences.

Milk Yield (MY):

Table 4 shows that the level of *LP* significantly affected (MY) from the first day of lactation up to the 7th week. A decrease in MY (129.3 vs 140.8g/h/d) was observed during the 0-7 week period when rabbits were fed diets containing 500g *LP*. However, this decrease was not consistent during the 7-14 and 14-21 week periods. MY during the 21-28 week period decreased (162.5 vs 173.8, P=0.004) with the adding of 500g *LP* in the diet. The results suggest that *LP* administered to does rabbits stimulated their milking potential, similar to findings in ewes (Zaleska *et al*., 2015). Milewski and Sobiech (2009) found that adding Saccharomyces cerevisiae dried brewer's yeast led to an increase in MY in sheep. Bakr *et al*. (2015) also found increased MY in yeast-supplemented cows. This rise in milk production may be qualified to factors such as increased dry matter intake, microbial protein flow to the duodenum, and the presence of vitamin B complex in yeast supplementation. Nevertheless, some research has not shown that giving cows probiotics increases their milk production. Probiotic supplementation in ewes and nursing cows has been linked to increases in MY in other studies. Overall, dietary supplementation of probiotics has been shown to improve productive and reproductive performances in lactating cows.

When the influence of *LP* level was not taken into account, the findings displayed that the NF had a noteworthy influence on milk production during the lactation period (0-28 weeks). Rabbits that were fed diets containing 0.3% and 0.5% NF had higher MY compared to the control group (P=0.004, 0.026, 0.008, and 0.004), respectively.

Table 4: MY g of Doe rabbits as affected by feeding diets supplemented with (*LP*) and/ or (NF).

Treatments	MY g/d/h			
	0-7Wks	7-14Wks	14-21Wks	21-28Wks
Main effect of *LP*:				
Control	140.8^{a}	186.1	205.5	173.8^{a}
500g *LP*	129.3^{b}	181.6	198.5	162.5^{b}

SEM	2.7	3.2	3.4	3.0
P value	0.001	0.231	0.087	0.004
Main effect of NF supplements				
0.0 NF	127.3^{b}	176.4^{b}	192.7^{b}	158.9^{b}
0.3 NF	139.8^{a}	188.0^{a}	206.7^{a}	173.0^{a}
0.5 NF	138.2^{a}	187.0^{a}	206.5^{a}	172.5^{a}
SEM	3.4	3.7	4.0	3.8
P value	0.004	0.026	0.008	0.004
Interaction effect *LP* × NF				
0.0g *LP* × 0.0 NF	125.6^{b}	168.6^{b}	186.1^{b}	156.9^{b}
0.0g *LP* × 0.3 NF	147.4^{a}	192.9^{a}	212.9^{a}	179.9^{a}
0.0g *LP* × 0.5 NF	149.5^{a}	196.7^{a}	217.3^{a}	184.6^{a}
500g *LP* × 0.0 NF	128.9^{b}	184.3^{ab}	199.2^{ab}	160.9^{b}
500g *LP* × 0.3 NF	132.1^{ab}	183.1^{ab}	200.4^{ab}	166.1^{b}
500g *LP* × 0.5 NF	126.9^{b}	177.4^{b}	195.8^{b}	160.5^{b}
SEM	3.0	3.4	3.7	3.6
P value	0.005	0.001	0.003	0.012

$^{a-b}$ different superscripts within a column indicate significant differences.

During the study's lactation periods, the additions of 0.3% and 0.5% NF to the baseline diet without LP increased MY more than the other experimental groups. The results also indicated that the positive control group had significantly lower MY values (P=0.005, 0.001, 0.003, and 0.012) compared to either the adverse controller group or the rabbits fed the same diet with supplementation.

Litter Size (LS):

In Table 5, the addition of *LP* to rabbit diets did not result in significant differences (P=0.712, 0.489, 0.572, 0.507, and 0.315) in LS for Total LS1, Live LS at Birth2, at 7Wks, at 14Wks, at 21Wks, and at 28Wks. LS at birth varied from 5.2 to 10.9 kits/doe according to Lukefahr *et al*., (1984); Yamani *et al*., (1994); Sakr, (2003), and Abd El Kafy, (2006). Brahmantiyo and Raharjo (2008) also noted that LS at birth can be influenced by genetic factors, breeding season, doe age, previous litter history, and nutritional level. In comparison to the doe rabbits fed a diet supplemented with the probiotic "ZOOVIT," the control group had an average of 2.98% more baby rabbits per doe (Dimova *et al*., 2017). However, the average number of weaned rabbits was 5.87 in the control group and 6.42 in the probiotic group. Abdel-Samee (1995) found similar results in experiments using the probiotic "Lacto-Sacc." The study showed a 16% increase in the number of live-born rabbits and an 11% increase in the number of weaned rabbits. Maertens and Ducatelle (1996) also observed that adding BIOSAF SC 47 from S.I. Lesaffre at a concentration of 10^{10} CFU/g to rabbit does led to a slight decrease in LS at parturition (9.6 No/h vs 9.4 No/h, P>0.1) and an increase at weaning (8 No/h vs 7.8 No/h, P>0.1).

Regardless of *LP* levels, the findings indicated that LS of TLS[1], LLS at Birth[2], and at 7Wks were not impacted by varying Na-Formate levels. However, the results presented in Table 5 demonstrated that the inclusion of 0.3% and 0.5% NF significantly increased the LS at 14Wks, 21Wks, and 28Wks (0.011, 0.05, and 0.05, respectively) compared to the control group. LS at weaning is influenced by various factors, primarily maternal care and milk production efficiency, which are largely determined by breed and parity (Askar, 1989; Yamani *et al*., 1992; Tawfeek, 1995). He *et al* (2016) reported that there was no significant difference in the total number of piglets born (P= 0.179) at birth between the group of animals that received sodium formate in their diets and the control group.

The data in Table 5 indicated that there was no significant effect of the interactions between the traits studied. However, the data revealed that TLS[1], LLS at Birth[2], at 7Wks, at 14Wks, at 21Wks, and at 28Wks were all improved in the supplemented treats compared to those that were not supplemented with *LP* in combination with NF (Negative control).

Table 5: LS (no)/ Doe rabbits as affected by feeding diets supplemented with (*LP*) and/ or (NF).

Treatments	LS (No)					
	TLS[1]	LLS[2]	7Wks	14Wks	21Wks	28Wks
Main effect of *LP*:						
0.0*LP*	6.79	6.40	6.20	6.03	5.94	5.56
500g *LP*	6.94	6.67	6.38	6.24	6.13	5.84
SEM	0.26	0.26	0.22	0.22	0.22	0.21
P value	0.712	0.489	0.572	0.507	0.523	0.315
Main effect of NF supplements						
0.0NF	6.6	6.3	6.0	5.7^{b}	5.6^{b}	5.2^{b}
0.3NF	6.8	6.6	6.3	6.2^{ab}	6.1^{ab}	5.8^{ab}
0.5NF	7.1	6.7	6.6	6.5^{a}	6.4^{a}	6.1^{a}
SEM	0.32	0.32	0.27	0.26	0.25	0.25
P value	0.601	0.634	0.256	0.011	0.05	0.05
Interaction effect *LP* × NF						
P value	0.921	0.850	0.875	0.768	0.380	0.210

$^{a\,b}$: different superscripts within a column indicate substantial changes.
[1]TLS=Total LS; [2]LLS= Live LS.

Litter Weight (LW):

The economic efficiency of rabbit productivity is influenced by the LW characteristic (Afifi *et al*., 1976). Including LP in doe rabbit diets did not result in significant differences (P=0.184, 0.990, 0.551, and 0.147) in LW at birth, 7 weeks, 14 weeks, and 21 weeks of nursing does rabbits. However, there was a significant difference (P=0.002) in LW at 28 weeks. Adding 500g of LP insignificantly increased LW by 1.92% and 13.19% from 14 to 21 weeks of nursing rabbits, respectively. This improvement is attributed to the fact that yeast or yeast culture is a rich source of vitamins, enzymes, and other important nutrients, acting as cofactors that enhance digestion and serve as a basic source of nutrients (Dawson, 1994). The change in LW at 21 days and at weaning appears to be correlated with the (MY) of the doe up to 21 days and weaning (Khalil, 1994). According to Zabek *et al*. (2014), adding a yeast product to a mother's diet during nursing or in late pregnancy and lactation had a significant impact on the development rate of her kids, which was explained by the mother's increased MY. Maertens and Ducatelle (1996) observed that adding BIOSAF LP 47, S.I. Lesaffre, at a concentration of 10^{10} CFU/g to doe rabbits tended to improve LW at parturition (65g vs 57g, P>0.1), after stabilization (68g vs 59g, P>0.1), at 3 weeks (409g vs 375g, P>0.1), and at weaning (647g vs 565g, P=0.03). Furthermore, Abdel-Rahman *et al*. (2012) and Mousa *et al*. (2012) observed that incorporating yeast into ewes' diets led to higher birth weights and increased weight gain in their offspring. Abou Ammou *et al.* (2013) showed that supplementing Damascus goats' rations with yeast culture at 2.5g/h/d or 5g/h/d levels resulted in higher birth and weaning weights, as well as increased total and daily weight gain in the kids born. Kassabra *et al*. (2013) observed the highest birth weight, weaning weight, and daily gain in the group supplemented with 8 g/h of dried yeast, followed by the group supplemented with 4 g/h of dried yeast, with the control group showing the lowest values (P<0.05). In a study conducted by Mostafa *et al*. (2014), it was discovered that adding commercial yeast culture (S. cerevisiae) at a rate of 35 g/d or a product of lactic acid bacteria and enzymes, AVI-BAC® (two probiotics), to the diet of lactating cows resulted in a significant increase in the birth weight of calves. Typically, smaller does give birth to lighter litters, as noted by Holdas and Szendro (2000). Furthermore, Seitz *et al*. (1998) found that a decrease in litter size is associated with an increase in the average individual birth weight due to improved nutrient availability per fetus during gestation in does with fewer offspring.

Regardless of the LP levels, the findings indicated that LW at birth and 7 weeks after birth were not impacted by varying levels of NF. However, the results presented in Table 6 demonstrated that the inclusion of 0.3% and 0.5% NF led to a significant increase (P=0.003, 0.039, and 0.05) in LW at 14, 21, and 28 weeks of nursing rabbits compared to the control group.

Data on the impact of different levels of NF on LW of doe's rabbits at various LP levels are shown in Tables 6. The addition of 0.3% and 0.5% NF to a basal diet without LP led to a higher increase in LW compared to other groups between 7 and 14 weeks of nursing rabbits. Similar results were seen in does rabbits fed a basal diet with 0.5% NF from 14 to 21 weeks. However, does rabbits fed diets containing 500g LP and 0.0 NF showed an increase in LW from 21 to 28 weeks of nursing rabbits. He *et al*. (2016) found that there was no significant difference in LW of piglets at birth (P = 0.063) between those receiving sodium Formate in their diets and the control group. Nevertheless, the mean body weight at day 7 tended to be higher in the NF group (P = 0.051), and the average daily gain of piglets was significantly greater (P = 0.011) in the NF group related to the regulator group.

It can be inferred that the inclusion of various levels of NF with or without LP supplementation in rabbit diets resulted in increased LW compared to the negative control group throughout the nursing periods. The BW gain of kits after birth is largely impacted by LS, as the amount of milk available per kit declines with larger litters.

Table 6: LW (g) /Doe rabbits as affected by feeding diets supplemented with (*LP*) and/ or (NF).

Treatments	LW (g)/doe				
	At birth	7Wks	14Wks	21Wks	28Wks
Main effect of *LP*:					
0.0 *LP*	343.5	735.9	1210.9	1672.9	2164.7^{b}
500g *LP*	321.2	736.3	1234.1	1739.4	2450.2^{a}
SEM	11.6	22.7	30.7	36.7	70.0
P value	0.184	0.990	0.551	0.147	0.002
Main effect of NF supplements					
0.0 NF	314.1	692.3	1123.1^{b}	1623.5^{b}	2150.4^{b}
0.3 NF	338.5	754.8	1263.8^{a}	1732.3^{a}	2387.0^{a}
0.5 NF	344.5	761.3	1280.5^{a}	1762.5^{a}	2385.0^{a}
SEM	14.2	26.8	35.3	42.4	85.4
P value	0.293	0.163	0.003	0.039	0.050
Interaction effect *LP* × NF					
0.0 *LP* × 0.0NF	312.3	668.2	1035.4^{c}	1481.4^{c}	1822.5^{c}
0.0 *LP* × 0.3NF	354.5	761.5	1285.4^{a}	1755.4^{ab}	2356.9^{b}
0.0 *LP* × 0.5NF	363.8	778.0	1311.8^{a}	1781.8^{a}	2314.8^{b}
500g *LP* × 0.0NF	316.0	716.3	1210.8^{b}	1765.5^{ab}	2478.3^{a}
500g *LP* × 0.3NF	322.4	748.1	1242.1^{ab}	1709.3^{b}	2417.1^{ab}
500g *LP* × 0.5NF	325.2	744.5	1249.3^{ab}	1743.3^{ab}	2455.2^{a}
SEM	16.6	31.1	41.6	48.1	91.0
P value	0.533	0.558	0.029	0.006	0.017

$^{a, b, c}$: different superscripts within a column indicate significant differences.

Blood biochemical

Serum TP, ALB and GLO concentrations

The results indicated that adding LP to V-line rabbit diets at the studied levels, regardless of Na-Formate supplementation, had an impact on serum TP, ALB, GLO concentrations, and the A/G ratio, (Table 7). Feeding 500g LP diets during mating and pre or post-partum periods significantly increased TP and ALB levels (P=0.001, 0.007, and 0.006). Dehydration is a common cause of increased ALB concentration, while decreased levels can be attributed to factors such as malnutrition, starvation, burns, sepsis, injuries, or liver and kidney diseases (Winnicka, 2004). The notable rise in blood ALB levels at various physiological stages indicates a healthy liver function, as the liver is responsible for producing ALB. These results are consistent with previous research conducted on sheep by El-Shaer (2003) and Mahrous and Abou-Ammou (2005), as well as on goats by Kholif (2001) and Abu-El-Ella and Kommonna (2013). The increase in albumin levels due to LP supplementation may be linked to enhanced nitrogen absorption. Serum albumin is considered a reliable indicator of nitrogen status, particularly in small ruminants (Ingraham and Kapple, 1988; Gaskins *et al.*, 1991; Laborde *et al.*, 1995). Additionally, albumin serves as a crucial reservoir for amino acids (White *et al.*, 1959). However, during the pre and post-partum periods, globulin levels were significantly higher (P=0.016 and 0.017) in V-line does rabbits fed a diet containing 500g LP compared to the control group. Additionally, rabbits fed the LP diet showed a significant increase (P=0.007) in the Albumin/globulin ratio at mating. The higher levels of serum TP in LP-treated animals may be due to the stimulation of cecum microbial protein synthesis by LP supplementation, leading to increased populations and activity of cellulolytic bacteria in the cecum. This, in turn, enhances fiber digestion, lactate utilization in the cecum, and the flow of microbial protein from the cecum to the duodenum (Guedes *et al*., 2008). Additionally, the higher levels of Glob in the LP-fed group may be due to an increase in net globulins, likely caused by elevated gamma globulins from Kupffer cell proliferation and a rise in plasma cell numbers in the bone marrow. This theory is backed by Buts *et al.* (1990), who discovered that giving S. cerevisiae orally to young rats led to a notable increase in IgA and secretory immunoglobulin components. However, there was no significant difference in serum ALB values (P>0.05) between the LP supplemented group and the control group during the entire study period. GLO levels were generally higher in the LP supplemented group (P>0.05), except on the 60th day of lactation, when a significant difference (P<0.01) was noted. The A/G ratio with 500g LP supplementation remained consistent before and after parturition. Various studies have shown that the typical range for the albumin/globulin ratio in blood serum is 0.8-1.3 (Salem *et al*., 2000; Komonna, 2007; Gabr *et al*., 2008). The findings are in line with those of El-Shaer (2003), Mahrous and Abou-Ammou (2005), and Komonna (2007) for sheep, as well as Kholif (2001) for goats, indicating that yeast culture supplementation did not impact the blood A/G ratio. Importantly, the A/G ratio values were above 1.0, suggesting that the animals did not experience any health issues affecting their performance, as noted by El-Sayed *et al.* (2002). When examining the influence of LP levels, the findings indicated that the addition of Na-Formate had a notable impact on serum TP levels. Specifically, only NF at a concentration of 0.3% demonstrated a significant (P=0.001) rise in TP levels during mating and pre and post-partum periods, along with a significant (P=0.017) increase in GLO levels compared to the control group that did not receive NF supplementation.

Table 7: Serum blood mg/dl of Doe rabbits as affected by feeding diets supplemented with (*LP*) and/ or (NF).

	Serum blood mg/dl											
	TP^{1}			ALB^{2}			GLO^{3}			A/G ratio^{4}		
Treatments	M$^{@}$	Pre$^{\%}$	Post$^{\&}$	M$^{@}$	Pre$^{\%}$	Post$^{\&}$	M$^{@}$	Pre$^{\%}$	Post$^{\&}$	M$^{@}$	Pre$^{\%}$	Post$^{\&}$
Main effect of *LP*:												
0.0 *LP*	5.26^{b}	5.30^{b}	5.40^{b}	2.81^{b}	2.73^{b}	2.83^{b}	2.45	2.58^{b}	2.57^{b}	1.16^{b}	1.07	1.12
500g *LP*	5.55^{a}	5.64^{a}	5.74^{a}	3.16^{a}	2.88^{a}	2.99^{a}	2.39	2.76^{a}	2.75^{a}	1.35^{a}	1.05	1.09
SEM	0.040	0.037	0.037	0.041	0.033	0.033	0.055	0.046	0.046	0.043	0.023	0.024
P value	0.001	0.001	0.001	0.001	0.007	0.006	0.455	0.016	0.017	0.007	0.803	0.748
Main effect of NF supplements												
0.0NF	5.30^{b}	5.33^{b}	5.43^{b}	3.02	2.76	2.87	2.28^{b}	2.57	2.56	1.35	1.08	1.12
0.3NF	5.51^{a}	5.57^{a}	5.67^{a}	2.98	2.88	2.99	2.52^{a}	2.69	2.68	1.19	1.08	1.13
0.5NF	5.41^{ab}	5.51^{ab}	5.61^{ab}	2.95	2.77	2.88	2.46^{ab}	2.74	2.73	1.23	1.03	1.07
SEM	0.055	0.057	0.057	0.064	0.042	0.042	0.064	0.055	0.055	0.056	0.028	0.028
P value	0.001	0.001	0.001	0.816	0.061	0.056	0.017	0.086	0.084	0.121	0.326	0.318
Interaction effect *LP* × NF												
P value	0.261	0.366	0.359	0.336	0.345	0.321	0.130	0.166	0.157	0.243	0.216	0.207

$^{a, b}$: different superscripts within a column indicate significant differences.
[1]TP=Total Protein; [2]ALB=Albumin; [3]GLO=Globulin; [4]A/G ratio= Albumin/Globulin Ratio
$^{@}$M=At mating; $^{\%}$Pre=Pre-partum; $^{\&}$Post=Post-partum.

The study observed the effects of combining LP supplementation with different levels of Na-Formate on serum TP, ALB, GLO, and their ratios. The groups treated with 500g LP + 0.0%, 0.3%, or 0.5% NF during mating or before and after delivery did not differ significantly from the negative control group, positive control group, or any of the other groups.

Serum blood Cholesterol (CHO), Triglycerides (TG) and Glucose

Serum blood CHO and glucose levels were significantly higher in does rabbits fed diets containing 500g LP at mating and during pre or post-partum compared to the control group (P=0.046, 0.05, 0.05, 0.004, 0.001, and 0.002) as shown in Table 8. In contrast to the control group, the rabbits' serum blood TG levels significantly decreased when 500g of LP was added to their meals (P=0.001, 0.001, and 0.004). This reduction could be attributed to enhanced lipid metabolism and utilization by the does rabbits, possibly due to their increased milk production (Stein *et al*., 2006).The elevated blood glucose levels may be due to the rapid hydrolysis and absorption of dietary carbohydrates in the digestive tract. This could be attributed to the action of amylase, leading to increased carbohydrate breakdown in the small intestine. Additionally, the increased activity of cellulolytic bacteria may contribute to the degradation of cellulose fibers, resulting in higher glucose production and elevated levels of the glucogenic precursor propionate in the rumen. This could also lead to a decrease in plasma insulin and insulin-glucose ratio, promoting gluconeogenesis. Furthermore, the higher production of propionic acid in cows fed with S. cerevisiae may be responsible for the increased glucose levels. Studies by Kholif and Khorshed (2006) showed that yeast culture supplementation in the diets of lactating buffaloes resulted in elevated blood glucose levels. Similarly, Abu El-Ella *et al*. (2014) reported that probiotic supplementation increased glucose and cholesterol levels during pregnancy and lactation, with a non-significant increase during mating. Zeedan *et al*. (2008, 2009) also observed that biogen probiotic supplementation led to increased total lipids, glucose, and cholesterol levels during various physiological stages. In a study by Bakr et al (2015), it was observed that animals supplemented with yeast had significantly higher serum glucose levels ($P<0.01$) compared to controls at 30, 45, and 60 days of lactation. Moreover, there was a notable decrease ($P<0.05$) in triglyceride levels at 60 days of lactation in the group receiving S. cerevisiae supplementation. The yeast-fed group exhibited significantly lower HDL levels ($P<0.05$) at 45 days of lactation, while LDL levels remained unaffected by the treatment. Additionally, there was a significant reduction in serum cholesterol concentrations in the yeast-fed group compared to the control group at 30 days ($P<0.01$), 45 days ($P<0.01$), and 60 days ($P<0.05$) of lactation.

When the impact of LP levels was not taken into account, the findings revealed that a low level of 0.3% NF supplementation had a notable impact on serum cholesterol. Specifically, only NF at the 0.3% level showed a significant (P=0.020) increase in cholesterol levels during mating and pre or post-partum compared to those supplemented with a high level of 0.5% Na-Formate or the non-supplemented group.

Table 8. Cholesterol (CHO), Triglyceride (TG) and Glucose (mg/dl) /Doe rabbits as affected by feeding diets supplemented with (*LP*) and/ or (NF).

	Serum blood (mg/dl)/doe rabbits								
	CHO[1]			TG[2]			Glucose[3]		
Treatments	Mating$^{@}$	Pre$^{\%}$	Post$^{\&}$	Mating$^{@}$	Pre$^{\%}$	Post$^{\&}$	Mating$^{@}$	Pre$^{\%}$	Post$^{\&}$
Main effect of *LP*:									
0.0 *LP*	172.06^{b}	171.83^{b}	171.56^{b}	74.15^{a}	74.16^{a}	64.03^{a}	93.72^{b}	94.87^{b}	96.17^{b}
500g *LP*	176.47^{a}	176.24^{a}	175.97^{a}	67.79^{b}	58.33^{b}	49.48^{b}	95.44^{a}	96.59^{a}	97.89^{a}
SEM	2.22	2.22	2.22	2.33	2.22	2.78	2.34	2.34	2.34
P value	0.046	0.05	0.05	0.040	0.001	0.001	0.004	0.001	0.002
Main effect of NF supplements									
0.0 NF	170.06^{b}	169.83^{b}	169.56^{b}	68.44	66.88	58.21	88.27	89.42	90.72

0.3 NF	180.79^{a}	180.56^{a}	180.29^{a}	71.08	66.46	58.74	100.96	102.11	103.41
0.5 NF	171.94^{b}	171.71^{b}	171.44^{b}	73.37	65.40	53.32	94.51	95.66	96.96
SEM	2.58	2.58	2.58	2.69	3.00	3.52	2.49	2.49	2.49
P value	0.020	0.021	0.020	0.797	0.155	0.310	0.175	0.188	0.190
Interaction effect *LP* × NF									
0.0 *LP* × 0.0 NF	166.75^{c}	166.52^{b}	166.25^{c}	69.77^{b}	69.88^{ab}	68.22^{ab}	81.79	82.94	84.24
0.0 *LP* × 0.3 NF	184.92^{a}	184.69^{a}	184.42^{a}	82.70^{a}	82.59^{a}	76.01^{a}	99.68	100.83	102.13
0.0 *LP* × 0.5 NF	164.51^{c}	164.28^{c}	164.01^{c}	69.97^{b}	70.02^{ab}	47.87^{b}	99.68	100.83	102.13
500g *LP* × 0.0 NF	173.38^{b}	173.15^{b}	172.88^{b}	67.12^{bc}	63.88^{ab}	48.21^{b}	94.75	95.90	97.20
500g *LP* × 0.3 NF	176.66^{ab}	176.43^{ab}	176.16^{ab}	59.47^{c}	50.33^{c}	41.47^{c}	102.23	103.38	104.68
500g *LP* × 0.5 NF	179.38^{ab}	179.15^{ab}	178.88^{ab}	76.77^{ab}	60.78^{b}	58.77^{b}	89.35	90.50	91.80
SEM	3.27	3.27	3.27	3.21	3.16	3.27	3.21	3.21	3.21
P value	0.001	0.005	0.005	0.001	0.002	0.001	0.066	0.071	0.089

$^{a, b, c}$: different superscripts within a column indicate significant differences.

^{1}CHO=Cholesterol; ^{2}TG=Triglyceride.

$^{@}$Mating=At mating; $^{\%}$Pre=Pre-partum; $^{\&}$Post=Post-partum.

Additionally, there was no important change in serum blood glucose levels (P=0.175, 0.188, and 0.190) among rabbits that were fed a diet with a low level of NF (0.3%). However, a decrease in serum blood glucose levels was noted in rabbits that were fed diets covering a high level of NF (0.5%) associated to the controller group.

The data in Table 8 indicated that there was a significant effect of the interactions between the traits studied. The data revealed that rabbits fed diets with 500g LP and 0.3% NF had higher levels of CHO and TG compared to rabbits on other diets, both supplemented and non-supplemented, during mating and pre or post-partum periods. There were no significant differences in serum blood glucose levels between the negative control group and the groups treated with 500g LP plus 0.0, 0.3, and 0.5% Na-Formate during mating or pre and post-partum.

Liver Function Determination:

Plasma asparatate aminotransferase (AST), alanine aminotransferase (ALT):

Enzymes called plasma transaminases (AST and ALT) help with gluconeogenesis by moving amino groups from one amino acid to another in live cells. Furthermore, Kuttler and Marble (1958) and Cornelius (1959) noted that serum transaminase levels are used as markers for diagnosing tissue necrosis, liver damage, and muscle degeneration. Alanine transaminase is an enzyme found inside liver cells, skeletal muscles, the heart, and kidneys. ALT plays a role in the conversion of glutamate and pyruvate by transferring an amino group from alanine to ketoglutaric acid. Elevated levels of ALT can designate viral hepatitis, liver damage from toxins, or metabolic issues, while low levels may suggest malnutrition or starvation.

Plasma alanine aminotransferase (ALT) concentration (Table 9) showed no significant change with the inclusion of 500g LP in the does' diet. A significant decrease (P=0.011, 0.004, and 0.004) in alanine aminotransferase (ALT) levels was observed in the groups of rabbits that were fed 500g LP in their diets during mating and pre- and post-partum periods. Results indicated that the addition of 500g LP to the diets of reproductive rabbits did not have a significant effect on serum AST levels compared to the control group at various stages. According to EI-Ashry *et al.* (2001) and EI-Shamaa (2002), ruminant diets including yeast culture had no discernible effect on ALT and AST activity. In contrast, Faten Abou Ammou *et al.* (2013) reported that adding yeast culture at levels of 2.5 and 5 g/h/d to the ration of

Damascus goats led to an increase in AST and ALT concentrations. Additionally, supplementing the ration of Damascus goats with 0.5 or 1.0 g/h/d of probiotic biogen resulted in a significant increase ($P<0.05$) in AST activity in response to both levels of biogen supplementation across various physiological stages. Moreover, ALT levels increased significantly ($P<0.05$) during pregnancy and lactation periods, while the increase was not significant during the mating period (Abu El-Ella *et al*., 2014).

Regardless of LP levels, the findings in Table *9* show that AST levels were significantly higher in rabbits fed diets with 0.5% NF compared to the control group. However, AST levels were lower in V-line rabbits fed a diet with 0.5% Na-Formate (P=0.012, 0.016, and 0.013). The AST levels found in this investigation fell within the typical physiological range.

Table *9*: Liver enztme as serum asparatate aminotransferase (AST µl) and serum alanine aminotransferase (ALT, µl) (mg/dl) /Doe rabbits as affected by feeding diets supplemented with (*LP*) and/ or (NF).

Serum blood (µl)/ doe rabbits	AST$^{@}$			ALT$^{\$}$		
Treatments	After mating	Pre-partum	Post-partum	After mating	Pre-partum	Post-partum
Main effect of *LP*:						
0.0 *LP*	64.65	64.95	65.98	59.08^{a}	48.98^{a}	58.06^{a}
500g *LP*	65.63	65.93	66.96	56.60^{b}	46.50^{b}	55.58^{b}
SEM	1.36	1.29	1.37	1.55	1.55	1.55
P value	0.824	0.812	0.821	0.011	0.004	0.004
Main effect of NF supplements						
0.0 NF	67.65^{a}	67.95^{a}	68.98^{a}	53.71^{b}	43.61^{b}	52.69^{b}
0.3 NF	65.68^{ab}	65.98^{ab}	67.01^{ab}	64.46^{a}	54.36^{a}	63.44^{a}
0.5 NF	62.09^{b}	62.39^{b}	63.42^{b}	55.34^{b}	45.24^{b}	54.32^{b}
SEM	1.58	1.59	1.59	1.49	1.50	1.51
P value	0.012	0.016	0.013	0.0001	0.0003	0.004
Interaction effect *LP* × NF						
0.0 *LP* × 0.0NF	65.10^{b}	65.40^{ab}	66.43^{b}	54.64^{c}	44.54^{c}	53.62^{c}
0.0 *LP* × 0.3NF	69.07^{a}	69.37^{a}	70.40^{a}	69.52^{a}	59.42^{a}	68.50^{a}
0.0 *LP* × 0.5NF	59.78^{c}	60.08^{c}	61.11^{c}	53.08^{c}	42.98^{c}	52.06^{c}
500g *LP* × 0.0 NF	70.20^{a}	70.50^{a}	71.53^{a}	52.79^{c}	42.69^{c}	51.77^{c}
500g *LP* × 0.3 NF	62.29^{bc}	62.59^{c}	63.62^{bc}	59.40^{b}	49.30^{b}	58.38^{b}
500g *LP* × 0.5 NF	64.41^{b}	64.71^{b}	65.74^{bc}	57.60^{bc}	47.50^{b}	56.58^{bc}
SEM	2.10	2.08	2.18	1.80	1.83	1.84
P value	0.01	0.011	0.01	0.001	0.002	0.0002

$^{a, b, c}$: different superscripts within a column indicate significant differences.

$^{@}$AST=aspartate-aminotransferase; $^{\$}$ALT= alanine-aminotransferase.

During mating and the pre- and post-partum periods, rabbits fed a diet with 0.3% NF showed significantly higher ALT levels (P=0.001, 0.0003, and 0.004) compared to both the control group and rabbits on a diet with 0.5% NF. The results in Table 8 indicated a notable impact of the interactions between the traits under study. Specifically, the data revealed that AST levels were elevated in female rabbits that were fed diets with both 0.0% LP and 0.3% NF or 500g LP and 0.0% NF compared to all other diet groups during mating, pre-partum, and post-partum periods. Furthermore, there was a significant rise in serum ALT levels in does that received diets with 0.0% LP and 0.3% NF compared to the control group or those given 500g LP with 0.0%, 0.3%, or 0.5% Na-Formate during mating, pre-partum, and post-partum stages.

CONCLUSION

In conclusion, supplementing V-line rabbit diets with Lactobacillus plantarum L and sodium formate improved reproductive performance, kit performance, and biochemical parameters. The most significant benefits were seen when both probiotics were combined in the diet with 0.3 and 0.5 g sodium formate.

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