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Research Article

Impact of different levels of probiotics on blood and biochemical parameters of local goat kids

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Abstract: This study was conducted for 105 days, including 15 days preliminary period aimed to investigate the effect of adding different levels of probiotics and concentrate diets on blood characteristics and serum biochemical parameters of local Iraqi goat kids. The study included 18 males of local goats at the age of 3 months with an average weight of 16.17±1.10kg. The kids were randomly distributed into 6 treatments with two levels of 40, and 60% and three levels of probiotics of 0, 2.5, and 5g/head/day. The probiotics were *Lactobacillus acidophilus* (10^8), *Bacillus subtilis* (10^9), *Bifidobacterium* (10^8, and *Saccharomyces cerevisiae* (10^9). The addition of the probiotic led to a significant increase in the level of glucose in the blood serum from 82.21mg/100 ml for the group of kids fed a 40% concentrated diet to more than 90.0mg/100 ml for the kids fed a 60% concentrated diet and to which a probiotic is added 2.5 or 5g/head/day. A significant decrease in cholesterol concentration was found in groups fed a concentrated diet of 60%. Triglycerides elevated from 23.86mg/100ml of kids fed 40% concentrate and 2.5mg probiotics/head/day to 29.17mg/100ml of kids fed 60% concentrate and 2.5g probiotics/head/day. In conclusion, the addition of the probiotic at the two levels 2.5 or 5g/ head/ day improved the biochemical and blood parameters of the animal.

Keywords: Probiotics, Antibiotics, Feeding, *Lactobacillus acidophilus*.
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Introduction

The use of antibiotics has resulted in controlling many diseases and improving the performance of animals (Zamojska et al. 2021). However, the increased use of antibiotics led to immunity and environmental concerns (Gemeda et al. 2020). In addition, the remnants of the antibiotics will enter the human body through the consumption of animal products, causing health problems (Faber et al. 2016). These issues have caused a decrease in the use of antibiotics to improve animal performance (Jouany & Morgari 2007). When searching for alternatives to improve animal performance and ensure health safety, probiotics are the proper candidates (Amin & Mao 2021). Probiotics are good alternatives due to the absence of any harm, contamination, residues, or side effects (Alayande et al. 2020). The preparation of the probiotics is done by selecting and isolating the microorganisms from nature (Salminen et al. 1999).

Probiotics also play an important role in the health of mammals by increasing their immunity and preventing diseases (Yuan et al. 2023). There are many probiotics that play a role in healing diseases (Zhang et al. 2022). *Lactobacillus plantarum* has an important role in reducing oxidative stress. These lactic acid bacteria have functions in preventing oxidation (Long et al. 2022). *Saccharomyces cerevisiae* can also produce a single-cell protein rich in zinc that can be introduced as feed supplements (Forough et al. 2022).

Adequate intake of probiotics improves the performance and health of goats (Angulo et al. 2019; Cai et al. 2019, 2021a, b; Taboada et al. 2022). The processing of yeast and *Clostridium butyricum*, both of which together lead to an improvement in fermentation in the rumen, which improves the growth of goats exposed to heat stress. The current study aimed to find out the effect of adding different levels of probiotics and concentrations of diets on blood characteristics and serum biochemical parameters of local Iraqi goat kids.

Materials and Methods

This study was conducted in the field of a goat breeder in the area of Karmachi, Karma Bani Saeed district, Souk Al-Shuyoukh district, Thi-Qar Governorate during 105 days, including 15 days preliminary period. A total of 18 local male kids were used in an individual feeding trial, with an average age of three months and weight of 16.17 kg. The probiotics were *Lactobacillus acidophilus* (10^8), *Bacillus subtilis* (10^9), *Bifidobacterium* (10^8, and *Saccharomyces cerevisiae* (10^9). Kids were divided into six nutritional groups (3 kids each), fed a concentrated diet consisting of 20% wheat flour, 25% wheat bran, 25% barley, 20% crushed corn, 7% soybean meal, and 3% salts and vitamins with rice hay treated with molasses and urea. The 1st diet group was the control group, 0g probiotics/head/day in addition to 40% concentrate + 60% rice straw. The 2nd group was given 2.5g probiotics/ head/ day in addition to 40% concentrate + 60% rice straw. The 3rd group was given 5g probiotics/ head/ day in addition to 40% concentrate + 60% rice straw. The 4th group was given 0g probiotics/ head/ day in addition to 60% concentrate + 40% rice straw. The 5th group was given 2.5g probiotics/ head/ day in addition to 60% concentrate + 40% rice straw). The 6th group was given 5g probiotics/ head/ day in addition to 60% concentrate + 40% rice straw. The kids were fed the concentrated diet at 3% of their body weight, a chemical analysis of concentrate diets and rice straw is shown in Table 1. The animals were examined by the veterinarian and all veterinary procedures were taken throughout the study period, as the kids were dosed against intestinal and hepatic worms using Al-Bendazole produced by the Italian company Doxal at a dose of 150mg/ kg live weight. The kids were also injected with Ivermctine (Norbrook, England) ($0.21 cm^3$/10kg live weight), subcutaneously.

Hematological parameters viz. erythrocytes, hemoglobin, packed cell volume, and white blood cells were calculated using the Genex Laboratories Count 60 device. Biochemical parameters were estimated using the kit prepared by the Tunisian Biomaghreb company, and the analyzes were performed based on the instruction manual attached to the kit by the manufacturer and using a spectrophotometer. The statistical program SPSS (2012) was used to analyze the data using a single-factor randomized design of six treatments and test for significant differences among means using the Revised Least Significant Differences (RLSD).

Results and Discussion

Biochemical parameters

Glucose, cholesterol, and triglycerides: Glucose, cholesterol, and triglycerides were affected significantly ($P<0.05$) by adding the probiotic to a diet consisting of 40 or 60% concentrated feed (Table 2). The group of kids fed a 60% concentrated diet with 2.5 or 5g probiotic/head/day showed significantly higher ($P<0.05$) glucose levels compared to the groups of chicks fed a 40% concentrate diet with a 2.5g/head/day probiotic. The reason may be attributed to the fact that the probiotic increases cellulolytic bacteria and lactic acid-consuming bacteria, and thus increases propionic acid, which is converted in the liver into glucose and excreted into the blood (Al-Galbi 2010). These results agreed with the findings of Muhammad (2016) in their study of Awassi lambs and Al-Galbi et al. (2017).

Table 1. Chemical analysis of experimental diets.

Nutrients	Concentrate %	Rice straw %
Dry matter	92.00	88.5
Crude protein	15.89	4.90
Ether Extract	3.25	1.92
Crude Fiber	6.99	29.23
NFE	70.81	40.95
Ash	3.06	11.50
NDF	21.76	73.60
ADF	6.15	64.90
ADL	3.56	25.70
Hemicellulose	15.61	8.70
Cellulose	2.59	39.20

Table 2. Mean of glucose, cholesterol and triglycerides (mg/100ml) of goat's kid fed different levels of concentrate supplemented with 2.5 or 5g/head/ day probiotics.

Treatments	Glucose	Cholesterol	Triglyceride
T1	82.21 ± 4.87^{b}	80.66 ± 4.45^{a}	25.77 ± 2.59^{ab}
T2	82.34 ± 4.85^{b}	72.22 ± 4.43^{b}	23.86 ± 2.62^{b}
T3	85.16 ± 4.83^{ab}	75.73 ± 4.0^{ab}	24.42 ± 2.60^{ab}
T4	92.09 ± 4.88^{a}	83.14 ± 4.50^{a}	26.13 ± 2.65^{ab}
T5	94.42 ± 4.95^{a}	70.11 ± 4.42^{b}	29.17 ± 2.66^{a}
T6	92.66 ± 4.91^{a}	71.24 ± 4.43^{b}	27.67 ± 2.64^{ab}

*T1=40% concentrate +0probiotics, T2=40%concentrate+2.5probiotics, T3=40%concentrate+5probiotics, T4=60%concentrate+0probiotics, T5=60%concentrate+2.5probiotics, T6=60%concentrate+5probiotics
*Means in the same column with different letters differ significantly at 0.05 level.

The increase in the level of glucose in the blood may be related to the hydrolysis of carbohydrates and their rate of absorption in the intestines of animals fed diets with yeast (Mousa et al. 2012). In healthy animals, all blood parameters are within normal ranges (Saleem et al. 2017). An increase in glucose concentration in blood parameters may occur as a result of an increase in the concentration of mannan-oligosaccharides, which is the primary factor in the increase of volatile fatty acids in the rumen resulting from carbohydrate fermentation by existing microorganisms and thus lead to an increase in the energy level of the animal (Milewski & Sobiech 2009). Dias et al. (2018) indicated that the increase in the level of glucose in the blood serum is probably the result of the conversion of starch present in the diet into propionic acid in the rumen as a result of fermentation by microorganisms that are activated by the addition of yeasts to the rumen that improves the environmental conditions of the rumen and the propionate is absorbed by the wall. It is converted into glucose in the liver, which leads to an increase in its level in the blood serum. The increase in glucose may be attributed to the ability of quercetin and apicin to increase glucose uptake and stimulate insulin secretion (Gutierrez et al. 2014). There are two sources of glucose in the blood, carbohydrate absorption from the gut and glycogenolysis in the liver (Bedford et al. 2020). In this study, an elevated serum glucose level was found, which is in agreement with the findings of Ma et al. (2021), Liu et al. (2022), and Yuan et al. (2023). As for cholesterol, the group of kids fed either 40 or 60% concentrate diet only outperformed the groups of kids fed a 40% concentrated diet with 2.5g probiotic/head/day and a 60% concentrate diet with 2.5 or 5g probiotic/head/day. The reason may be attributed to the fact that the development of the body and the rapid increase in weight leads to an increase in the demand for cholesterol in the production of hormones, especially sexual ones since the lambs are at the beginning of their sexual maturity (Mousa et al. 2012). Hassan & Mohammed (2016) obtained similar results when feeding Awassi lambs with yeast. The probiotics secrete an enzyme that analyzes the bile salts, decomposes the gelatin or taurine associated with the bile salts, and produces fatty acids and free bile salts, which are less soluble than those associated with them and are pushed out, which necessitates the production of more salts and consumption of cholesterol for the body to compensate (Corzo & Gilliland 1999; Al-Galbi 2010). Some probiotics stick to cholesterol to build the cell wall and prevent the remaining part from being absorbed by the intestines and from being transported into the bloodstream (Noh et al. 1997). The results of this study agreed with the studies of Al-Galbi et al. (2017) and Al-Ghazi (2022).

While the triglycerides level of the group fed a 60% concentrated diet with 2.5gm probiotic/head/day excelled over that of the group fed a 40% concentrated diet with 2.5g probiotic/head/day. Perhaps the increase in the concentrations of triglycerides in the animal groups fed probiotic diets is due to its association with an increase in the level of glucose (Milewski & Sobiech 2009). Or as a result of a high level of the hormone insulin, which contributes to the metabolism of fat in the liver, an increase in the concentration of propionic and butyric acid in the rumen and the production of glucose and gastrin (Antunovic et al. 2006).

Total protein, albumin, and globulin: The level of total protein, albumin, globulin, and the ratio of albumin/ globulin were not significantly affected by the level of concentrated feed and the addition of probiotics to the local goat kids' diets (Table 3). While the level of globulin was affected significantly ($P<0.05$) according to the differences in the percentage of the concentrated diet and the addition of the probiotic. The two groups of kids fed a diet containing 60% concentrated fodder with the probiotic added by 2.5 or 5g/head/day outperformed ($P<0.05$) the group of kids fed a 40% concentrated diet only. The reason for the significant superiority in the level of globulin may be attributed to the improvement of the health and immunological status of these kids, which reduces the chances of disease, reduces the costs of veterinary health treatments, and improves the performance of animals (Al-Galbi et al. 2017). Giving probiotics to ruminants has a beneficial effect on the health and safety of the digestive system, reducing diarrhea and protecting against infectious diseases (Long et al. 2022), increasing the beneficial microorganism products present in the rumen, and reducing the mortality of young kids at their early ages during the period before weaning (Ayala-Monter et al. 2019).

Blood parameters: The numbers of white blood cells, red blood cells, and hemoglobin concentration were not significantly affected by the difference in the percentage of concentrated diet and the addition of the probiotic (Table 4). While the packed volume cell was significantly affected ($P < 0.05$) by the difference in the percentage of concentrated diet and the addition of the probiotic. Kids fed a 40% concentrated diet with 2.5 or 5 g/head/day and groups fed 60% concentrated diet and the additive of 2.5 or 5g/head/day excelled the two groups of kids fed either 40 or 60% concentrated diet only.

The reason for the significant increase in the blood parameters may be attributed to the fact that yeast contains the mineral elements necessary to build blood, the increase in red blood cells, and the increase in PCV (Al-Khafaji et al. 2011). These results agreed with those obtained by Ibrahim & Hassan (2015), when they fed bread yeast to Awassi rams. The noticeable increase in PCV is also attributed to its direct correlation with the number of red blood cells, as they correlate positively (Hussein 2018).

Table 3. Total serum protein, albumin, globulin (g/100 ml) and albumin/ globulin ratio of goat's kid fed different levels of concentrate supplemented with 2.5 or 5g/head/day probiotics.

Treatments	Total protein	Albumin	Globulin	Albumin/ Globulin
T1	7.00±0.99[a]	3.34±0.45[a]	3.66±0.37[b]	0.91±0.03[a]
T2	7.76±0.98[a]	3.66±0.47[a]	4.10±0.35[ab]	0.89±0.04[a]
T3	7.96±0.96[a]	3.78±0.46[a]	4.18±0.39[ab]	0.90±0.03[a]
T4	7.79±0.99[a]	3.75±0.45[a]	4.04±0.34[ab]	0.93±0.03[a]
T5	8.72±1.00[a]	4.22±0.48[a]	4.50±0.35[a]	0.94±0.03[a]
T6	8.53±1.10[a]	4.13±0.47[a]	4.40±0.33[a]	0.94±0.04[a]

*T1=40% concentrate +0probiotics, T2=40%concentrate+2.5probiotics, T3=40%concentrate+5probiotics, T4=60%concentrate+0probiotics, T5=60%concentrate+2.5probiotics, T6=60%concentrate+5probiotics
*Means in the same column with different letters differ significantly at 0.05 level.

Table 4. Blood parameters of goat kids fed different level of concentrate supplemented with 2.5 or 5g/head/day probiotics.

Treatments	White Blood Cells x10^3	Red Blood Cells x10^6	Hemoglobin (gm/100 ml)	Packed Cell Volume %
T1	6.93±0.72[a]	5.22±0.78[a]	10.10±1.15[a]	34.00±1.54[b]
T2	5.87±0.74[a]	5.77±0.75[a]	10.25±1.20[a]	35.50±1.53[a]
T3	5.66±0.69[a]	5.81±0.79[a]	10.63±1.18[a]	36.14±1.53[a]
T4	6.66±0.73[a]	5.44±0.74[a]	10.40±1.14[a]	34.00±1.57[b]
T5	5.76±0.75[a]	6.56±0.78[a]	11.50±1.17[a]	38.38±1.54[a]
T6	5.83±0.74[a]	6.44±0.76[a]	11.63±1.16[a]	37.11±1.55[a]

*T1=40% concentrate +0probiotics, T2=40%concentrate+2.5probiotics, T3=40%concentrate+5probiotics, T4=60%concentrate+0probiotics, T5=60%concentrate+2.5probiotics, T6=60%concentrate+5probiotics
*Means in the same column with different letters differ significantly at 0.05 level.

These results agreed with the study of Al- Nassar (2017), Al-Galbi et al. (2017) and (Al-Ghazi 2022).

References

Al Nassar, M.R.K. 2017. Effect of dosing different levels of kefir milk as a bioenergetic enhancer on the performance of male lambs in Orabi sheep. Thesis, College of Agriculture, University of Basrah, 114 p.

Alayande, K.A.; Aiyegoro, O.A. & Ateba, C.N. 2020. Probiotics in animal husbandry: applicability and associated risk factors. Sustainability 12(3): 1087.

Al-Galbi, H.A.J.; Al-Galbi, M.K.; A.Shwaa, I.A. & Jnam, A.A. 2017. Effect of using Saccharomyces cerevisiae with baggaz on blood and biochemical parameters of Arabi lambs blood serum. Journal of College of Education for Pure Sciences (JCEPS) 7(1): 174-183.

Al-Galibi, H.A.J. 2010. Effect of different percentages of the biocomponent and the corn cohort in the digestion and performance of Arabian lambs. PhD thesis-Faculty of Agriculture, University of Basra, 175 p.

Al-Ghazi, N.K.J. 2022. Effect of adding celery seeds as a probiotic to local goat diets in some productive characteristics. Thesis University of Thi-Qar. 164 p.

Al-Khafaji Al-Wazeer, A.A.M.; Al-Khuzai, H.M.H.; Al-Marsumi, T. & Al-Marsumi, S.F. 2011. Effect of adding different levels with baker's yeasts and black seeds on some blood and biochemical traits in Arrabi Sheep Lambs. Al-Qadisiyah Journal of Veterinary Medicine Sciences 10(2): 111-116.

Amin, A.B. & Mao, S. 2021. Influence of yeast on rumen fermentation, growth performance and quality of products in ruminants: a review. Animal Nutrition 7(1): 31-41.

Angulo, M.; Reyes-Becerril, M.; Cepeda-Palacios, R.; Tovar-Ramírez, D.; Esteban, M.Á. & Angulo, C. 2019. Probiotic effects of marine *Debaryomyces hansenii* CBS 8339 on innate immune and antioxidant parameters in newborn goats. Applied Microbiology and Biotechnology 103(5): 2339-2352.

Antunović, Z.; Šperanda, M.; Amidžić D, Šerić V, Stainer Z, Domačinović & M, Boli F. 2006. Probiotic application in lamb's nutrition. Krmiva 48: 175-180.

Ayala-Monter, M.A.; Hernández-Sánchez, D.; González-Muñoz, S.; Pinto-Ruiz, R.; Martínez-Aispuro, J.A.; Torres-Salado, N. & Gloria-Trujillo, A. 2019. Growth performance and health of nursing lambs supplemented with inulin and *Lactobacillus casei*.

Asian-Australasian Journal of Animal Sciences 32(8): 1137.

Bedford, A.; Beckett, L.; Harthan, L.; Wang, C.; Jiang, N.; Schramm, H.; Guan, L.; Daniels, K.M.; Hanigan, M.D. & White, R.R. 2020. Ruminal volatile fatty acid absorption is affected by elevated ambient temperature. Scientific Reports 10(1): 13092.

Cai, L.; Hartanto, R.; Zhang, J. & Qi, D. 2021a. Clostridium butyricum improves rumen fermentation and growth performance of heat-stressed goats in vitro and in vivo. Animals 11(11): 3261-3270.

Cai, L.; Yu, J.; Hartanto, R. & Qi, D. 2021b. Dietary supplementation with Saccharomyces cerevisiae, *Clostridium butyricum* and their combination ameliorate rumen fermentation and growth performance of heat-stressed goats. Animals 11(7): 2116-2124.

Cai, L.Y.; Yu, J.K.; Hartanto, R.; Zhang, J.; Yang, A.; Qi, D.S. 2019. Effects of heat challenge on growth performance, ruminal, blood and physiological parameters of Chinese crossbred goats. Small Ruminant Research 174: 125-130.

Corzo, G. & Gilliland, S. 1999. Measurement of bile salt hydrolase ac-tivity from Lactobacillus acidophilus based on disappearance of con-jugated bile salts. Journal of Dairy Science 82(3): 466-471.

Dias, A.L.G.; Freitas, J.A.; Micai, B.; Azevedo, R.A.; Greco, L.F.; & Santos, J.E.P. 2018. Effect of supplemental yeast culture and dietary starch content on rumen fermentation and digestion in dairy cows. Journal of Dairy Science 101(1): 201-221.

Faber, F.; Tran, L.; Byndloss, M.X.; Lopez, C.A.; Velazquez, E.M.; Kerrinnes, T.; Nuccio, S.P.; Wangdi, T.; Fiehn, O.; Tsolis, R.M. & Baumler, A.J. 2016. Host-mediated sugar oxidation promotes post-antibiotic pathogen expansion. Nature 534(7609): 697-699.

Forough, S.; Kumarss, A.; Azam, H. & Mohaddeseh, L. 2022. Application of Saccharomyces cerevisiae isolated from industrial effluent for zinc biosorption and zinc-enriched SCP production for human and animal. Food Science and Technology 42: e82021.

Gemeda, B. A., Amenu, K., Magnusson, U., Dohoo, I.; Hallenberg, G.S.; Alemayehu, G.; Desta, H. & Wieland, B. 2020. Antimicrobial use in extensive smallholder livestock farming systems in ethiopia: knowledge, attitudes, and practices of livestock keepers. Frontiers in Veterinary Science 7: 55.

Gutierrez, R.M.P.; Juarez, V.A.; Sauceda, J.V. & Sosa, I.A. 2014. In vitro and in vivo antidiabetic & antiglycation properties of apium 111 graveolens in type 1 & 2 diabetic rats. International Journal of Pharmacology 10(7): 368-379.

Hassan, S.A. and Mohammed, S.F. 2016. Effect of Saccharomyces cerevisiae supplementation on rumen characteristics in Awassi lambs fed diets with different roughage to concentrate ratios. The Iraqi Journal of Agricultural Sciences 47(Special Issue): 1-11.

Hussein, A.F. 2018. Effect of probiotics on growth, some plasma bio-chemical parameters & immunoglobulins of growing Najdi lambs. World's Veterinary Journal 8(4): 80-89.

Ibrahim, S.S. & Hassan, S.A. 2015. Effect of using feed blocks containing different nitrogen sources and with or without peaker yeast on blood characteristics of Awassi rams. Al-Anbar Journal of Veterinary Sciences 8(1): 37-49.

Jouany, J.P. & Morgavi, D.P. 2007. Use of ‘natural’ products as alternatives to antibiotic feed additives in ruminant production. Animal 1(10): 1443-1466.

Liu, S.; Shah, A.M.; Yuan, M.; Kang, K.; Wang, Z.; Wang, L.; Xue, B.; Zou, H.; Zhang, X.; Yu, P.; Wang, H.; Tian, G. & Peng, Q. 2022. Effects of dry yeast supplementation on growth performance, rumen fermentation characteristics, slaughter performance and microbial communities in beef cattle. Animal Biotechnology 33(6): 1150-1160.

Long, L.; Meng, X.; Sun, J.; Jing, L.; Chen, D. & Yu, R. 2022. Ameliorated effect of *Lactobacillus plantarum* SCS2 on the oxidative stress in HepG2 cells induced by AFB1. Food Science and Technology 42: e16522.

Ma, J.; Wang, C.; Wang, Z.; Cao, G.; Hu, R.; Wang, X.; Zou, H.; Kang, K.; Peng, Q.; Xue, B.; Wang, L.; Zhu, Y.; & Zhu, X. 2021. Active dry yeast supplementation improves the growth performance, rumen fermentation, and immune response of weaned beef calves. Animal Nutrition 7(4): 1352-1359.

Milewski, S. & Sobiech, P. 2009. Effect of dietary supplementation with Saccharomyces cerevisiae dried yeast on milk yield, blood biochemical and haematological indices in ewes. Bulletin of the

Veterinary Institute in Pulawy 53: 753-758.

Mohammed, S.F. 2016. Effect of addition of commercial bakers yeast saccharomyces cerevisiae and Iraqi probiotic on digestion, weight gain and some blood parameters in Awassi sheep. Kufa Journal for Agricultural Science 8(3): 329-309.

Mousa, K.M.; El-Malky, O.M.; Komonna, O.F. & Rashwan, S.E. 2012. Effect of live dried yeast supplementation on digestion coefficients, some rumen fermentation, blood constituents and some reproductive and productive parameters in Rahmani sheep. Journal of American Science 8: 291-303.

Noh, D.O.; Kim, S.H. & Gilliland, S.E. 1997. Incorporation of choles-terol into the cellular membrane of Lactobacillus acidophilus ATCC 43121. *Journal of dairy science*, *80*(12), 3107-3113.

Saleem, A.M.; Zanouny, A.I. & Singer, A.M. 2017. Growth performance, nutrients digestibility, and blood metabolites of lambs fed diets supplemented with probiotics during pre- and post-weaning period. Asian-Australasian Journal of Animal Sciences 30(4): 523-530.

Salminen, S.; Ouwehand, A.; Benno, Y. & Lee, Y.K. 1999. Probiotics: how should they be defined? Trends in Food Science & Technology 10(3): 107-110.

SPSS. 2012. Statistical Packeges for Social Sciences. Version 20. Manual. USA.

Taboada, N.; Fernández Salom, M.; Córdoba, A.; González, S.N.; López Alzogaray, S. & van Nieuwenhove, C. 2022. Administration of selected probiotic mixture improves body weight gain and meat fatty acid composition of Creole goats. Food Bioscience 49: 101836. 6.

Yuan, K.; Ma, J.; Liang, X.; Tian, G.; Liu, Y.; Zhou, G.; Chen, Y. & Yang, Y. 2023. Effects of microbial preparation on production performance and rumen microbial communities of goat. Food Science and Technology 43:1-8.

Zamojska, D.; Nowak, A.; Nowak, I. & Macierzyńska-Piotrowska, E. 2021. Probiotics and postbiotics as substitutes of antibiotics in farm animals: a review. Animals 11(12): 3431.

Zhang, M.; Wang, J. & Yang, Z. 2022. Immunomodulatory and antitumor activities of the exopolysaccharide produced by potential probiotic Lactobacillus plantarum YW11 in a HT-29 tumor-burdened nude mouse model. Food Science and Technology 42: e57822.