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Impact of Supplementation of Probiotic or Prebiotic in the diet on growth performance, nutrient digestibility, and rumen parameters of Iraqi goats' kids

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Abstract: This study was conducted to assess the effects of probiotic or prebiotic dietary supplements on the nutrient digestibility, rumen fermentation characteristics and productive performance of local Iraqi goat kids. A concentrate feed mixture (CFM) and alfalfa hay were provided to the kids in the control group. Kids in T1 and T2 groups received CFM supplemented with probiotics or prebiotics at a rate of 3 g/head/day, respectively. Fifteen males' Iraqi local kids aged three months and weighed 16.22 kg ± 2.3 were used. The kids were randomly assigned into the three nutritional groups. Kids fed probiotics show superiority to those in the control group in their final body weight, total gain, average daily gain, total feed intake and feed conversion ratio (5.84 vs 6.65 kg/ kg). The group that received probiotic supplements had the highest Dry matter, organic matter, crude protein, crude fiber, and ether extract digestibility. pH, total VFA and propionate% increased with the addition of probiotics or prebiotics compared to the control group. Whereas, the control group recorded the highest acetate% followed by the probiotics (63.27%) and prebiotics group (64.26%). The total bacterial count of the probiotics group was higher than that of the prebiotics or a control group. Feeding growing kids rations supplemented with probiotics or prebiotics at a rate of 3 g/head/day has a positive impact on the growth performance, rumen parameters, digestibility coefficients, and rumen microbes of Iraqi goats.

Keywords: Digestibility, Goat kids, Performance, Prebiotics, Probiotics.

Introduction

Because the population of natural probiotic bacteria likely increases by the addition of prebiotic molecules as powerful surface absorbing agents, they augment fecal density with the expected useful effect of longer life of infecting agents in the external environment. In any case, this effect doesn't remove the importance of the competitive aspect of the probiotics, as well as if some of them are also able to produce inhibitor agents or work with bacteriocins (Mohamed *et al*., 2022; Ban & Guan, 2021). One of the most important properties of probiotics is the capacity to prevent infectious diseases by competitive exclusion mechanisms. Probiotic bacteria metabolize a portion of food and produce volatile fatty acids (VFA). These three molecules are an important energy source for the host, contribute to growth, and help maintain a constant rumen-saline osmotic pressure. Furthermore, 70-80% of VFA is absorbed and metabolized in animal tissues (Zeedan *et al.*2023).

Administering live microorganisms (probiotics) in adequate amounts, enhance health benefit of the host. Through the mutualism between both groups, a healthy and stable relationship is developed. The understanding about the mechanism between probiotics and the native microbiota and their characteristics has brought new insight about the importance of probiotics as a tool to reinforce the benefits provided by the native microbiota. (Iranmanesh, 2021)

The prebiotic approach and synbiotic is very recent. Ruminants have been known to have a symbiotic relationship with microorganisms. The overall metabolic activities of the rumen microbes are often directed by the proportion of the specific microbial population that prevails in the rumen. These microorganisms allow the host animal to efficiently utilize its typical diet of roughages. (Iranmanesh, 2021 & Zeedan *et al.*2023)

Therefore, the aim of this study was the use of probiotics or prebiotics in goats' nutrition have a protective effect on their digestive system, promote growth performance and improve nutrient digestibility.

Materials & Methods

This study was undertaken in a private farm of goat Thi Qar/ Shatra. Fifteen local male kids were offered in an individual feeding trial, with three months average age and 16.22 kg body weight. Kids were distributed on three nutritional groups. The 1st group (control) was fed 60% concentrate feed mixture (CFM) and 40% alfalfa hay. The 2nd group fed control diet supplemented with 3 g/ animal/ day probiotics. The 3rd group fed control diet supplemented with 3gm/ animal/ day prebiotics. One gram of probiotics contains *Lactobacillus acidophilus* 10^8, *Bacillus subtilis* 10^9, *Bifidobacterium* 10^8, and *Saccharomyces cerevisiae* 10^9. Prebiotics was from BioBoost^{TM} (50% mannan + 50% b-glucan), manganese sulphate monohydrate 2g, vitamin A 0.12g and vitamin E 0.13. Carrier bentonite 500g). As 3.5% of their life body weight, the kids were provided the diet. Table (1) displays the results of the chemical analysis of alfalfa hay and concentrate diets. Throughout the trial time, the kid received veterinary examinations and treatments, and the Italian business Doxal created Al-Bendazole, which is used to treat intestinal and hepatic worms in kids at a dose of 150 mg/kg living weight. Additionally, the kids received subcutaneous injections of Ivermectin (0.21 cm^3 10 kg^{-1} live weight), which is manufactured by the English company, Nor Brook.

Table (1). **Chemical composition of concentrate feed mixture and Alfalfa hay (% on Dry matter basis) used in the current experiment**

Chemical Composition	Concentrate diet	Alfalfa Hay
Dry Matter	89.72	91.11
Crude protein	12.89	16.4
Ether Extract	3.33	1.28
Crude Fiber	7.20	32.28
Ash	2.58	6.75
Nitrogen Free Extract	63.70	34.40
Metabolizable energy (MJ/kg)	11.85	8.88

- **The metabolizable energy was calculated according to the** Ministry of Agriculture, Forestry and Fisheries (MAFF, 1975) **as follows: ME (MJ/kg) = 0. 012CP + 0.031EE + 0.005CF + 0.014NFE CFM: 54% Barley grain, 30% Wheat bran, 10% Yellow corn, 5% Soya bean meal, and 1% Vitamin & Minerals. Vitamin A (12000 000 IU), Vitamin D3 (2200 000 IU), Vitamin E (1000 mg), Vitamin B1 (1000 mg), Vitamin B2 (4000 mg), Vitamin B6 (100 mg), Vitamin B12 (10 mg), Pantothenic acid 3.33 g, Biotin 33 mg, Folic acid 0.83 g, Zinc 11.79 g, Mn 5 g, Fe 12.5 g, Cu 0.5 g, Se 16.6 mg, and Mg 66.7 g are all included in one kilogram of premix.**

Kids receive meals twice a day at 8:00 and 16:00. Water for drinking was always accessible. The study lasted 105 days, including 15 days for adaptation. Quantitative collections of urine and feces were made once a day, at eight in the morning, before meals. Every day, about 15% of the extracts from the urine and feces were taken daily. Samples of feces were kept at -18°C, whereas samples of urine were kept tightly sealed vials containing a 1:1 solution of sulfuric acid to extract NH3. After thoroughly mixing each animal's seven-day collection of feces, they were dried for 48 hours at 60°C. Dry matter was determined. The remaining material was ground up in a Wiley mill using a 1 mm sieve. The dry matter foundation has been used to test and express the digestibility of various nutrients. The pH of the rumen fluid was measured by using pH meter (9900) after withdrawn immediately. The fluid was sieved using fourfold cheese making cloth. The volatile fatty acids were measured by GC mas' device.

NH_3-N was determined by the phenol-hypochlorous acid colorimetric method using a visible spectrophotometer at a wavelength of 550 nm as described by (He *et al*., 2024).

The data were analyzed using a single component randomized design of three treatments using the statistical software SPSS (2019). The Least Significant Differences (LSD) was employed to assess for significant differences among means.

Results & Discussion

Growth performance

Table 2 shows that growing kids received diet supplemented with probiotic had superiority ($P<0.05$) in final body weight, Total gain, average daily gain and total feed intake as compared with those fed control diet the feed conversion ratio had improved significantly ($P<0.05$) in kids fed probiotic than those fed prebiotic and control diet. In contrast to the control group, kids received prebiotics showed a substantial ($P<0.05$) increase in their average daily gain, total feed intake, and feed conversion ratio. Improved microbial nitrogen movement in the large intestine from consistent microbiota composition at the rumen, and small, and large intestines of calves may be the cause of higher body weights (Kiernan *et al*., 2023). On the other hand, the significantly increased of average daily gain (ADG) and improved ($P<0.05$) feed conversion ratio (FCR) may also point to diets' enhanced capacity to raise body weight (Elliethy *et al*., 2022). Probiotics have also been demonstrated to optimize ruminal fermentation and increase nutrient digestibility, which improves goat growth performance (Bouchicha *et al*., 2021). Probiotic or prebiotics supplementation enhanced productivity, nutritional absorption and digestibility in dairy goats (Sahoo *et al.,* 2020). Probiotic and concentrate supplementation increased the growth rate and feed conversion efficiency of Osmanabadi goat kids (Siddiqui *et al*., 2022). These outcomes concur with those of Sivadasan & Subramannian (2020), who used three-month-old male crossbred Malabari goat offspring. Similarly, Osman *et al* (2023) have demonstrated a favorable impact of probiotic supplementation on weight growth that is comparable to this effect.

. **Table 2. Effect of supplementing either probiotic or prebiotic to the diet on growth performance of growing kids (mean ± SE)**

Traits	Control	Probiotics	Prebiotics
Initial Body Weight (kg)	$16.36^{a}\pm0.23$	$16.24^{a}\pm0.14$	$16.06^{a}\pm0.11$
Final Body Weight (kg)	$25.85^{b}\pm1.13$	$28.24^{a}\pm1.21$	$27.05^{ab}\pm1.17$
Total gain (kg)	$9.49^{b}\pm1.22$	$12.00^{a}\pm1.20$	$10.99^{ab}\pm1.25$
Average Daily Gain (g/head/day)	$105.44^{c}\pm14.25$	$133.33^{a}\pm14.17$	$122.16^{b}\pm13.23$
Total feed intake (kg)	$697.95^{b}\pm21.20$	$778.40^{a}\pm21.30$	$745.15^{a}\pm22.19$
Feed Conversion Ratio (kg/kg)	$6.65^{c}\pm0.22$	$5.84^{a}\pm0.31$	$6.10^{b}\pm0.23$

- **Mean values with different superscripts on the same row differ significantly ($p < 0.05$).**

Table 3. Digestibility coefficients of different nutrients of goats' kid received either probiotics or prebiotics (mean ± SE)

Traits	Digestibility Coefficients (%)		
	Control	Probiotics	Prebiotics
Dry Matter	$70.84^{c}\pm0.37$	$74.20^{a}\pm0.39$	$72.89^{b}\pm0.37$
Organic Matter	$71.84^{c}\pm0.45$	$75.00^{a}\pm0.48$	$73.99^{b}\pm0.47$
Crude Protein	$70.44^{c}\pm0.65$	$73.77^{a}\pm0.67$	$72.16^{b}\pm0.63$
Crude Fiber	$64.56^{c}\pm0.66$	$70.21^{a}\pm0.68$	$68.25^{b}\pm0.69$
Ether Extract	$63.95^{c}\pm0.61$	$69.40^{a}\pm0.71$	$65.11^{b}\pm0.69$
Nitrogen Free Extract	$66.67^{b}\pm0.76$	$72.33^{a}\pm0.56$	$71.98^{a}\pm0.62$

Mean values with different superscripts on the same row differ significantly ($p < 0.05$)

Digestibility coefficients

Probiotic or prebiotic supplementation improves ($P<0.05$) the digestibility of all nutrients as seen in Table 3. The group that received probiotic supplements had the highest DM, OM, CP, CF, and EE digestibility. Compared to the control and prebiotics groups, such values were higher. the nutrients above, a prebiotic-supplemented group of kids outperformed ($P<0.05$) the control group. In either case, the NFE digestibility coefficients of the probiotic and prebiotic-supplemented groups were greater ($P<0.05$) and comparable to those of the control group. Probiotic supplementation may have increased the numbers of cellulolytic bacteria in the rumen and improved rumen pH (Saleem *et al*., 2017). The current results are consistent with other studies. Awassi lambs fed a diet supplemented with 3 g/day yeast culture, YC improved nutrient digestibility of DM, OM and apparent CP compared to other groups (Haddad & Goussous, 2005). Mukhtar *et al*., (2010) reported that the digestibility of DM and CP were higher in lambs fed concentrate with probiotics compared to lambs fed concentrate only. Supplementing the diet of growing lambs with probiotics improved the digestibility of DM, OM, CP, CF, EE, and NFE compared to control, but differences in nutrient digestibility were not significant except for CP digestibility. On the other hand, supplementing the diet of weaned lambs (Ding *et al*., 2008) or goats (Whitley *et al*., 2009) with probiotics did not affect the digestibility of DM, OM and CP compared to the control group.

Rumen fermentation parameters

pH value and volatile fatty acids concentration of kids supplemented with either probiotic or prebiotics were shown in Table (4). Kids received probiotic or prebiotics exhibited higher ($P<0.05$) pH value, total VFA, acetate, propionate and butyrate than those of control group. pH value and total VFA concentration increased significantly ($P<0.05$) with the addition of probiotic or prebiotic in comparison with those in control group. Molar percentage of propionate showed significant ($P<0.05$) differences between the control, probiotic and prebiotics group. Whereas, control group recorded the highest acetate% value in comparison with probiotics group and prebiotics group.

Rumen pH was found to decrease when growing lambs were supplemented with Saccharomyces uvarum or an equal mixture of *Kluyveromyces marximanus, Saccharomyces cerevisiae,* and *S. uvarum*

(Kowalik *et al*., 2011; Tripathi & Karim, 2011). Other studies have shown that probiotics administered via food managed the rumen's pH (Chaucheyras-Durand *et al*., 2008), leading to efficient rumen functioning and a decreased risk of sub-acute ruminal acidosis (Lettat *et al*., 2012). The rumen pH was stabilized as a result of this increasing effect, which may be related to the probiotic's potential to create a more O2-free ruminal environment that is advantageous for increasing the relative abundance of lactate-utilizing bacteria and improving lactate consumption in the rumen (Amin & Mao, 2021). Numerous mechanisms have been found to account for how probiotics affect the fluctuation of rumen pH. Probiotics could lower the quantity of lactic acid generated through competing with Lactobacilli and/or *Streptococcus bovis* for the use of glucose (Chaucheyras-Durand *et al*., 2008).

Table (4) Rumen fermentation parameters of kids supplemented with either probiotic or prebiotic (mean± SE)

Items	Control	Probiotics	Prebiotics
pH	5.64^{c}±0.04	6.35^{a}±0.05	6.19^{b}±0.05
NH3-N (mg/100 ml rumen fluid)	10.23^{a}±1.25	7.65^{b}±1.12	8.95^{b}±1.23
Total VTA (mmol/100 ml rumen fluid)	66.86^{b}±4.75	77.10^{a}±5.38	74.97^{a}±5.49
Acetate Molar%	68.47^{b}±0.35	63.27^{a}±0.37	64.26^{a}±0.33
Propionate Molar%	18.56^{b}±0.36	23.21^{a}±0.38	21.25^{a}±0.39
Butyrate Molar%	8.95^{c}±0.61	9.40^{a}±0.71	9.11^{b}±0.69
Isovalerate Molar%	1.68^{b}±0.14	2.19^{a}±0.17	2.00^{ab}±0.16
Acetate: Propionate	3.69^{c}±0.13	2.72^{a}±0.10	2.99^{b}±0.11

- **Mean values with different superscripts on the same row differ significantly (P < 0.05). VFA=Volatile Fatty Acids,** NH3-N= Ammonia nitrogen concentration

Conversely, probiotics have the potential for releasing malate and short peptides, which could subsequently encourage *Megasphaera elsdenii* and *Selenomonas ruminantium* to consume L-lactate (Kholif *et al*., 2024). Additionally, as ruminal protozoa compete with *S. bovis* for glucose uptake and can metabolize lactic acid, probiotics can alter the quantities of these bacteria in the rumen (Galip, 2006), which regulate lactic acid concentrations (Kholif *et al*., 2024). Furthermore, compared to amylolytic bacteria, rumen protozoa can digest starch more slowly (Mendoza *et al*. 1993). A decrease in the release of methane resulting low energy loss could be the cause of the increase in overall VFA levels in animals fed with probiotics, because more energy would be used for VFA (Williams & Newbold, 1990. Nevertheless, in growing lamb or mature goats fed probiotic-supplemented diets, several studies found a significant decrease in ruminal VFA development (Kowalik *et al.* 2011, Tripathi & Karim, 2011). However, probiotic feed additives have not been shown to have an impact on the overall VFA concentrations in the rumen, according to certain researchers (Galip, 2006, Tripathi *et al*. 2008, Soren *et al*. 2013).

Microbial count in rumen

In the rumen fluid of the goat kids undergoing the investigation, the total count of bacteria and cellulolytic bacteria was estimated (Table 5). The overall bacterial count of kids who got probiotics was (18.75x 10^{8} CFU/ml of rumen fluid) higher (P<0.05) than that of the groups that received prebiotics (14.29 x 10^{8} CFU/ml of rumen fluid) or a control group (9.32 x 10^{8} CFU/ml of rumen fluid). As for the numbers of cellulolytic bacteria, the rumen fluid to which the probiotic was added had significantly higher numbers (P<0.05) compared to the group adding the prebiotic and the control group, which amounted to 2.00 x 10^{8} CFU/ml of rumen fluid. The variety and richness of rumen microbiota were in line with the findings of Jia *et al.* (2018) investigation. By facilitating the identification of several uncultivable microorganisms and additional novel genes or genomes, metagenomics has significantly improved our comprehension of the make-up of their microbial communities. Using metagenomic analysis, Bicer *et al*. (2021) compared the microbiota of commercial and traditional kefir, demonstrating that the latter had a higher microbial diversity than the former (Biçer *et al*., 2021). Given that Krokmach's microflora has unique qualities, Dimov (2022) carried out a metagenomics study to examine the peculiar microbiota of this traditional dairy product from Bulgaria.

Table (5) Total bacteria and cellulolytic bacteria count in the rumen fluid of kids supplemented with probiotic or prebiotic (mean ± SE)

Items	Control	Probiotics	Prebiotics
Total bacteria count × 10^8 (CFU/ml rumen fluid)	9.32^c±0.42	18.75^a±0.58	14.29^b±0.05
Cellulolytic bacteria count ×10^8 (CFU/ml rumen fluid)	2.43^c±0.25	7.62^a±0.32	5.25^b±0.23

- **Mean values with different superscripts on the same row differ significantly (P < 0.05).**

Conclusion

Based on the aforementioned findings, it is possible to draw the conclusion that feeding growing kids diet supplemented with probiotics or prebiotics at a rate of 3 g/head/day has a positive impact on the growth performance, rumen parameters, digestibility coefficients and rumen microbes of local Iraq goats. The effect of adding probiotics to the diet was more noticeable. Additional research is required to elucidate the mode of action of these compounds and to ascertain the ideal supplementation amounts for use with different types of farm animals and production scenarios.

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Contributions of authors

M.K.A.A: Research idea, collecting samples, lab work and writing. **R. H. M.:** writing and reviewing the article, **H. A. J. A:** research idea, lab work, the statistical analysis the data.

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Conflicts of interest

We declare that there is no conflict of interest.

Ethical approval

All applicable national and international guidelines for the care and use of animals were followed.

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تأثير إضافة المعزز الحيوي أو السابق الحيوي الى العليقة على أداء النمو ومعامل هضم العناصر الغذائية ومعايير الكرش لجداء الماعز العراقي

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المستخلص: أجريت هذه الدراسة لتقييم تأثير إضافة المعزز الحيوي أو السابق الحيوي على قابلية هضم العناصر الغذائية وخصائص التخمر في الكرش والأداء الإنتاجي لجداء الماعز العراقي المحلي. تم توفير خليط الأعلاف المركزة (CFM) ودريس الجت لجداء مجموعة السيطرة. قسمت الجداء الى مجموعتين T1 و T2غذيت الأعلاف المركزة مضافًا إليه البروبيوتيك أو البريبايوتيك بمعدل 3 غم / رأس / يوم على التوالي. تم استخدام خمسة عشر من ذكور الماعز المحلي العراقي تراوحت أعمارهم بين ثلاثة وأربعة أشهر بوزن 16.22 كغم ± 2.3. تم توزيع الجداء عشوائيًا على المجموعات الغذائية الثلاث. أظهر الجداء الذين تغذوا المعزز الحيوي تفوقًا على أولئك في مجموعة السيطرة في وزن الجسم النهائي والزيادة الوزنية الكلية ومتوسط الزيادة اليومية وإجمالي تناول العلف وكفاءة التحويل الغذائي (5.84 مقابل 6.65 كغم / كغم). اظهرت المجموعة التي غذيت المعزز الحيوي أعلى قابلية هضم للمادة الجافة والمادة العضوية والبروتين الخام والألياف الخام ومستخلص الأثير. ارتفع الآس لهيدروجيني وانتاج الاحماض الدهنية الكلية ونسبة حامض البروبيونك مع إضافة المعزز الحيوي أو السابق الحيوي مقارنة بمجموعة السيطرة، في حين سجلت مجموعة السيطرة أعلى نسبة أسيتات تليها مجموعة المعزز الحيوي (63.27%) ومجموعة السابق الحيوي (64.26%). كان عدد البكتيريا الكلية في مجموعة المعزز الحيوي أعلى من مجموع السابق الحيوي أو مجموعة السيطرة. إن تغذية الجداء النامية بعلائق مكملة بالمعزز الحيوي أو السابق الحيوي بمعدل 3 غرام/رأس/يوم له تأثير إيجابي على أداء النمو ومعايير الكرش ومعاملات الهضم وميكروبات الكرش لدى الماعز العراقية.

الكلمات المفتاحية: الهضم، جداء الماعز، الأداء، المعزز الحيوي، السابق الحيوي.