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Research article

EFFECT OF THE REARING SYSTEM ON THE ESTABLISHMENT OF DIFFERENT FUNCTIONAL GROUPS OF MICROORGANISM IN THE RUMEN OF KID GOATS

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This study was aimed to determine the effect of the rearing system on the establishment and development of different functional groups of microorganisms in the rumen of kid goats. Fifty kids were fed on goat milk until weaning at 45 (TR, traditional rearing system, n = 25) and 30 days of age (alternative rearing system, AR, n = 25). In addition, only AR group was offered with rumen starter from birth. Both groups consumed alfalfa hay and ground corn between 30 and 90 days of age. Five kids from each group were slaughtered at 21, 30, 45, 70 and 90 days old. It was determined the total number of protozoa, anaerobic, amylolytic and cellulolytic bacteria present in the rumen. Kids of AR were lighter in weight than TR kids between 42 and 56 days old. In both rearing systems, anaerobic and amylolytic bacteria were found at 21 days of age, while cellulolytic and protozoa were not found until 45 days of age. Kids of AR had higher quantities of anaerobic and amylolytic bacteria until 30 and 45 days of age, respectively. These results demonstrate the rearing system does not affect the sequence and time in which the functional groups of microorganisms are established in the rumen. However, the alternative rearing system with early intake of solid food allowed the establishment of greater amount of bacteria and protozoa. Nevertheless, the effect of weaning on growth rate was more marked in kids from alternative rearing system, despite its greater microbiological rumen development.

Key words: kid goats, rearing system, rumen microbiology

INTRODUCTION

In the first weeks of life ruminants depend exclusively on nutrients obtained from milk because the rumen is undeveloped. The establishment of microbiota and beginning of ruminal fermentation triggered rumen development [1]. At birth, the intestinal tract of animals is sterile. The establishment of ruminal microbiota is influenced primarily by diet and by contact with other adult ruminants that already have a developed

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microbiota [2]. The ruminal ecosystem of an adult animal is composed mainly of anaerobic microorganisms, including bacteria, fungi and protozoa, characterized by high population density and wide diversity [3]. Ruminal bacteria can be classified according to the substrates that they ferment. Thus, bacteria that ferment starch, cellulose and hemicellulose are classified within the group of amylolytic, cellulolytic and hemicellulolytic, respectively [4,5]. Taken together these groups represent the population of total anaerobic rumen bacteria. Diet is one of the main factors that affect the type and proportion of functional groups of bacteria present in the rumen of an adult ruminant. Forage diets stimulate the development of fibrolytic flora, while high energy concentrate diets stimulate the growth of amylolytic bacteria [6]. Newborn ruminants have no protozoa in their rumen environment, and it is well known that young ruminants incorporate the protozoa by inoculation from an adult animal. The salivation of food by an adult animal and the subsequent intake of this contaminated food by a young ruminant determine the beginning of the faunation [2].

Many authors have reported that supply of solid feed from an early age stimulates rumen development [7-9]. Rumen development comprises anatomical (increase of size and weight), microbiological (establishment of microbial populations) and metabolic changes (absorption and utilization of fermentation products) [6]. There are numerous studies in which are described the effect of different feeding regimes and weaning ages on the anatomic and metabolic rumen development [6,7,9-11]. However, studies on microbial development of the rumen in young animals are scarce. In addition, there were not found studies assessing the effect of different rearing systems on the establishment and development of rumen microbiota in kid goats.

Furthermore, in most studies of ruminal microbiology conducted in adult ruminants, the isolation and counting of microorganism were done from samples of ruminal contents [2,12-14]. The microbial concentration (microorganisms per gram of rumen contents) in those samples is considered representative of the total amount of microorganisms in the rumen (microbial concentration multiplied by weight of rumen contents), because size and contents of the rumen are relatively constant in adult ruminants [15]. However, this could be different in young kid goats during transition from lactating to ruminant, because the size and capacity of the rumen increases as it develops [10,16]. For the above reason, to assess properly the functional groups of ruminal microorganism in young kid goats during the transition period, it was considered necessary to determine if the microbial concentration is representative of the total number of microorganisms present in the rumen.

In this study two hypotheses were considered: 1) young kids with developing rumen will have varying amounts of rumen contents so the microbial concentration will not be representative of total quantity of microorganisms present inside the rumen; 2) the establishment and development of different functional groups of bacteria and protozoa on the rumen will be determined by rearing system. Therefore, kids fed with solid ruminal starter and weaned early will achieve an earlier rumen microbiological

development than kids raised under a traditional system of rearing. The objectives of this study were 1) to determine the relationship between quantity of rumen contents, microbial concentration and total number of microorganisms in the rumen of kids at different ages; and 2) to determine the effect of rearing system on the establishment and development of different functional groups of microorganisms in the rumen of kid goats.

MATERIALS AND METHODS

Animals and treatments

All experimental procedures and animal care practices were in agreement with provisions of the Guide for Care and Use of Agricultural Animals in Research and Teaching [17]. Fifty single-born Criollo male kids with their respective mothers were selected from the farmer household of "La Majada" (32º19'39'S, 67º54'36'W) located in the department of Lavalle, Mendoza, Argentina. The animals were moved with their mothers to the facilities of the Argentinean Institute for Arid Land Research (IADIZA) located at the Science and Technology Center CONICET Mendoza, Argentine (CCT Mendoza CONICET). Kid goats were assigned to two treatments (n=25), balancing groups according to their birth body weight (BW, 2.92 ± 0.31 kg). Animals were separated from their mothers at 3 days of age and were placed in individual closed pens (1.5 x 0.75 m), with cement floors bedded with wood shavings. Thereafter, goat kids were allowed to suckle milk from their respective mothers for about 30 min twice daily at 07^{30} and 19^{30} h until weaning either at 30 (AR, alternative rearing group) or 45 days of age (TR, traditional rearing group). In addition, goat kids in AR group were ad libitum offered with a commercial starter diet from beginning of trials until 45 days of age, and a ration composed of alfalfa hay and ground corn (80 % and 20 % on dry matter basis, respectively) from 30 to 90 days of age. Goat kids in TR group did not receive the commercial starter diet but were ad libitum offered with ration between 30 and 90 days of age. Starter and ration were provided twice daily at 08^{00} and 20^{00} h. The feeding scheme of kid goats according to rearing system is shown in Table 1. All animals were treated for parasites with ivermectin (0.2 mg kg BW^{-1}) and vaccinated against clostridial organisms. Adult goats were all in their third to sixth birth, weighed 36.5 ± 4.7 kg and had a body condition score of 2.03 ± 0.21 (scale 1 to 5). During nursing of kids, goats were fed 1 kg of alfalfa hay and 0.5 kg of ground corn on dry matter basis. Clean drinking water and mineral licks were always available ad libitum. Composition of mineral licks (in g per kg, as specified by the manufacturer) was: Ca (31.2), P (3.3), Mg (25.3), S (1.7), Na (93.5), K (2.4), Zn (2.5), Cu (1.5), Se (0.1), I (0.2), and Mn (2.5). During the trial period the minimum, maximum and mean temperature registered at pens was 14.0, 28.5 and 20.4 º C, respectively.

Table 1. Feeding scheme according to the rearing system and age of kids (days)

Rearing system	Goat Milk	Rumen Starter[1]	Ration[2]
AR	1-30	1-45	30-90
TR	1-45	–	30-90

[1]Ruter®, ACA; [2]Ration consisted of alfalfa hay (80%) and ground corn (20%).
AR, alternative system with rumen starter and early weaning age (30 days old);
TR, traditional system without rumen starter and traditional weaning age (45 days old)

Sampling and determinations

Goat milk, rumen starter, alfalfa hay and ground corn were sampled weekly for the determination of nutritional composition. Chemical composition of milk was determined in the Laboratory of Food Quality, EEA INTA Salta and rumen starter and ration were analyzed in the Laboratory of Nutrition and Forage Quality Assessment, EEA INTA Balcarce. Nutritional composition of different diets offered to kid goats is shown in Table 2.

Table 2. Nutritional composition (on dry matter basis) of diets offered to kids during the trials

	Composition, on DM basis (g kg^{-1})		
	Goat milk[1]	Rumen Starter[2]	Ration[3]
Dry matter	135	930	901
Crude protein	42	249	152
NDF		135	456
ADF		61	295
Ether extract	40	92	28
Ash	9	58	98
ME MJ/kg	3.08	16.2	8.8

[1]Composition expressed per kg of fresh milk. The concentration of milk metabolizable energy (ME) was estimated according to the equation: MJ kg^{-1} = 1.4694 + (0.4025 × milk fat %) [45].
[2]Ruter®, ACA; [3]Ration consisted of alfalfa hay (80%) and ground corn (20%)

Kid goats were weighed weekly before the morning meal. Milk intake was measured twice a week as the difference between kid's body weight before and after suckling [18]. Rumen starter and ration intake were measured daily as the difference between offered and refused. Milk, starter, ration and solid food intake (expressed as % of BW) were averaged every 15 days.

Five kids from each group were randomly selected and slaughtered at 21, 30, 45, 70 and 90 days of age after a 12 h fasting with free access to water. Rumen dissection was performed following the methodology described by Lesmeister et al. [19]. The rumen was removed from the carcass, washed with water, dried and weighed with

content (filled rumen weight). Thereon, an incision was made in the rumen wall and 75 ml of homogenized rumen contents were taken for microbial counts. Then, the ruminal content was removed and the rumen was washed and weighed again (empty rumen weight). The rumen content was estimated as the difference between full and empty rumen weight. The pH of rumen contents was determined with a glass electrode immediately after sample taking. From samples of rumen content the concentration (microrganisms per gram of rumen content) of protozoa and total anaerobic, cellulolytic and amylolytic bacteria was determined. The concentrations of these microorganisms were multiplied by weight of rumen content, obtaining the total number of protozoa (Proto-Total), anaerobic bacteria (Anaero-Total), cellulolytic bacteria (Cellulo-Total) and amylolytic bacteria (Amylo-Total). The culture media and procedures for microorganism counts were performed according to Grilli et al. [14] for bacteria and Dehority [2] for protozoa.

Statistical analysis

All data were statistically analyzed using the GLM procedure of InfoStat statistical software [20]. The Pearson correlation coefficients between total microbial numbers, weight of rumen contents and microbial concentration were calculated at each slaughter age.

The total number of microorganisms (Anaero-Total, Cellulo-Total, Amylo-Total, Proto-Total) was transformed (log_{10}) before statistical analysis.

Milk, starter, ration and solid food intake, pH and total number of microorganisms were analyzed according to the following model:

$$Y_{ijk} = \mu + R_i + Tj + RT_{ij} + \epsilon_{ijk}$$

where Y_{ijk} = dependent variable; μ = overall mean; R_i = fixed effect of rearing system; T_j = fixed effect of time; RT_{ij} = treatment x time interaction effect, and ϵ_{ijk} = experimental error. When not significant ($P > 0.05$), interaction was excluded from the model.

Body weight data were analyzed with a repeated measures design according to the following model:

$$Y_{ijk} = \mu + R_i + T_j + A_k + \epsilon_{ijk}$$

where Y_{ijk} = dependent variable; μ = overall mean; R_i = fixed effect of rearing system; T_j = fixed effect of time; A_k = random kid goat effect, and ϵ_{ijk} = experimental error.

The covariance structure for each variable analyzed was chosen by comparing several models with different covariance structures. The covariance structure yielding the lowest AIC value (Akaike's Information Criterion) was selected [21]. When effects of treatment, time or treatment x time interaction were significant, differences between means were determined by Fisher's LSD test, considering differences statistically significant when $P < 0.05$.

RESULTS

Intake and growth performance of kid goats according to age and rearing system

The daily consumption of milk, starter, ration and solid food is shown in Table 3. No significant differences were found in daily milk intake between rearing systems during the suckling period. Rumen starter intake was negligible before 15 days of age; therefore it was measured from that time. Ration intake of AR kids from 31 to 75 days of age was higher (P <0.001) than that of TR kids. The same differences were found when total solid food intake was expressed as a percentage of body weight. Between 76 and 90 days of age no significant differences were observed in feed intake between groups. During the first 15 days after weaning, solid food intake was similar (P >0.05) for both groups of kids in spite of the different ages at weaning (1.95 % BW between 31-45 days old and 1.80 % BW between 46-60 days old, for AR and TR groups, respectively). No statistically significant differences were found (P >0.05) in body weight between groups from 7 to 35 days of age (Figure 1). Body weight of AR kids at 42, 49 and 56 days of age was lower (P <0.05, P <0.01, P <0.01, respectively) than body weight of TR kids. While from 63 days of age until end of the trial no differences were found between kids from both rearing systems.

Table 3. Mean intakes of goat milk, starter and ration according to rearing system and kid age

		Rearing system		
Item	**Age (d)**	**TR**	**AR**	**SEM**
Milk intake, g DM d^{-1}	3-14	149.7	149.1	5.8
	15-30	144.2	152.7	6.3
	31-45	149.3	-	3.7
Starter intake, g DM d^{-1}	15-30	-	11.6	1.3
	31-45	-	27.3	1.1
Ration intake, g DM $d^{-1\infty}$	31-45	48.1[a]	78.1[b]	2.9
	46-60	173.3[a]	241.9[b]	21.1
	61-75	289.6[a]	395.4[b]	51.2
	76-90	491.9	534.7	49.2
Solid food intake, % BW [#]	15-30	-	0.19	0.01
	31-45	0.59[a]	1.95[b]	0.19
	46-60	1.80[a]	2.79[b]	0.14
	61-75	2.78[a]	3.81[b]	0.37
	76-90	4.07	4.43	0.41

[ab]Means in the same row with different letters differ significantly (P <0,05); [#]Solid food intake does not take account milk intake; [∞]Ration consisted of alfalfa hay (80%) and ground corn (20%). AR, alternative system with rumen starter and early weaning age (30 days old); TR, traditional system without starter diet and traditional weaning age (45 days old); SEM, Standard error of the mean

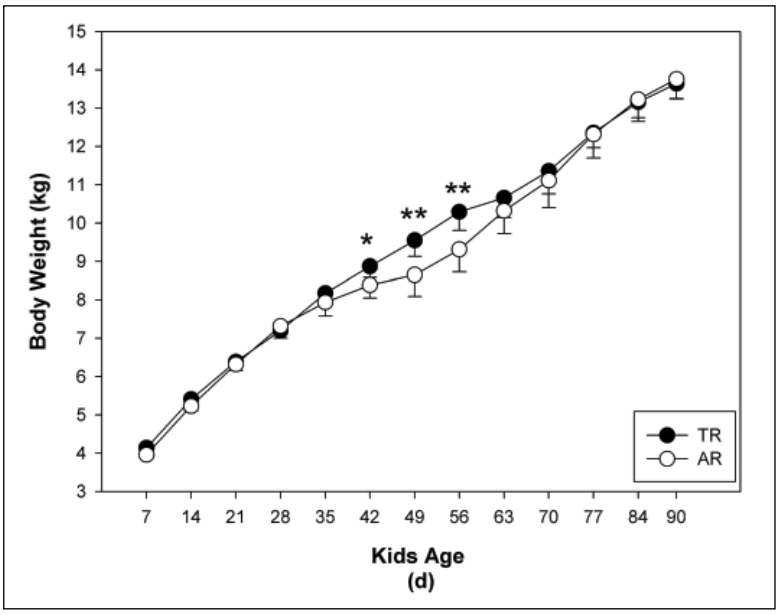

Figure 1. Mean bodyweight of kids according to age and rearing system
AR, alternative rearing system with rumen starter and early weaning age (30 days old);
TR, traditional rearing system without rumen starter and traditional weaning age (45 days old)
* P <0.05 ** P <0.01

Relationship between rumen contents, microbial concentration and total number of microorganisms according to the age of kids

The correlation coefficients between total number of microorganisms, weight of rumen contents and microbial concentration according to age of kids are presented in Table 4. In kids 21 and 30 days old, significant correlation coefficients were observed between Anaero-Total and Amylo-Total with microbial concentration (P <0.001); and with rumen content (P <0.001). Since 45 days of age until end of the study the total number of microorganisms showed higher correlation coefficients (P <0.001) with microbial concentration than with rumen content. In this period, correlation coefficients between rumen content and Anaero-Total were observed only at 90 days of age (P <0.05); and between rumen content and Proto-Total at 45 and 90 days of age (P <0.05).

Functional groups of rumen microorganisms according to the rearing system of kid goats

The pH values and Anaero-Total, Cellulo-Total, Amylo-Total and Proto-Total counts according to the rearing system and age of kid goats are presented in Table 5. The ruminal pH of AR kid goats at 21, 30 and 45 days of age was lower (P <0.001, P <0.001, P <0.01, respectively) than that of TR kid goats. In both groups, anaerobic

and amylolytic bacteria were present from 21 days of age, whereas cellulolytic bacteria and protozoa were not detected until 45 days of age. AR kid goats showed higher counts of Anaero-Total at 21 ($P < 0.01$) and 30 ($P < 0.001$) days of age compared to TR kid goats. From 45 days of age no differences were found in the number of Anaero-Total bacteria between groups of kid goats. AR kid goats showed higher quantities of Amylo-Total bacteria at 21, 30 and 45 days of age ($P < 0.001$) with respect to TR kid goats. After 70 days of age no differences were detected in Amylo-Total bacteria between groups of kids. Throughout the whole assay no differences were found in Cellulo-Total and Proto-Total counting between kids of both groups.

Table 4. Pearson correlation coefficients between total microbial numbers, weight of rumen contents and microbial concentration according to the age of kids

Age (d)	Total microbial number	Microbial concentration	Rumen content
21§	Anaero-Total	0.91***	0.94***
	Amylo-Total	0.89***	0.97***
30§	Anaero-Total	0.98***	0.96***
	Amylo-Total	0.98***	0.97***
45	Anaero-Total	0.98***	0.03
	Amylo-Total	0.96***	-0.49
	Cellulo-Total	0.99***	0.22
	Proto-Total	0.86***	0.78*
70	Anaero-Total	0.94***	0.30
	Amylo-Total	0.97***	0.62
	Cellulo-Total	0.97***	0.23
	Proto-Total	0.89***	0.39
90	Anaero-Total	0.93***	0.68*
	Amylo-Total	0.92***	-0.19
	Cellulo-Total	0.95***	0.27
	Proto-Total	0.94***	0.77*

§At 21 and 30 days old cellulolytic bacteria and protozoa were not found in the rumen *$P < 0.05$, ***$P < 0.001$. Anaero-Total, Amylo-Total, Cellulo-Total and Proto-Total are the total number (microbial concentration multiplied by rumen content) of anaerobic, amylolytic, cellulolytic and protozoa present in the rumen, respectively.

Table 5. Mean pH and total number of bacteria and protozoa present in the rumen according to the rearing system and age of kids

Age (d)	pH			Total number of ruminal microorganisms											
				Anaero-Total (10^{11} UFC)			Amylo-Total (10^{11})			Cellulo-Total (10^{10})			Proto-Total (10^{8})		
	AR	TR	SEM	AR	TR	SEM	AR	TR	SEM	AR	TR	SEM	AR	TR	SEM
21§	5.5[a]	6.7[b]	0.3	2.9[a]	0.5[b]	0.5	5.6[a]	0.1[b]	9.7						
30§	5.5[a]	6.6[b]	0.2	36.6[a]	1.1[b]	6.2	28.2[a]	0.5[b]	4.7						
45	6.5[a]	6.8[b]	0.1	5.1	3.2	0.9	34.2[a]	12.5[b]	3.7	0.2	0.1	0.1	3.0	3.5	0.2
70	6.7	6.8	0.1	4.5	0.9	0.9	10.3	14.7	2.5	1.6	3.3	0.6	3.8	4.6	0.6
90	6.6	6.3	0.1	23.4	10.9	3.7	27.8	26.8	0.9	1.9	1.0	0.3	4.7	2.6	0.7

[ab] Mean values in the same row with different letters differ significantly ($P<0.05$).
§ At 21 and 30 days old cellulolytic bacteria and protozoa were not found in the rumen.
AR, alternative system with rumen starter and early weaning age (30 days old).
TR, traditional system without rumen starter and traditional weaning age (45 days old).
UFC: Colony Forming Units. SEM, Standard error of the mean
Anaero-Total, Amylo-Total, Cellulo-Total and Proto-Total are the total number (microbial concentration multiplied by rumen content) of anaerobic, amylolytic, cellulolytic and protozoa present in the rumen, respectively.

DISCUSSION

Intake and growth of kids according to age and rearing system

The AR Kid goats did not consume detectable amounts of rumen starter before 15 days of age. This is consistent with reports by Baldwin and Jesse [22] and Khan et al. [9], who revealed that calves and lambs do not consume significant quantities of solid feed before two weeks of age. The rumen starter intake observed in kids in our study is similar to that reported by Luo *et al.* [23] in Spanish kid goats at 5-6 weeks of age (21.7 g DM d^{-1}). The higher ration intake of AR kids compared to TR kids indicates that the alternative rearing system with weaning at 30 days of age encouraged earlier consumption of solid food. This is because there is an inverse relationship between the intake of milk and solid feed consumption [9,24,25]. Therefore, when milk supply is reduced or stopped the intake of solid feed increases significantly [9,26]. This explains why, between 31 and 45 days of age, the consumption of solid food of AR kids was higher than that of TR kids who were still drinking goat milk. In addition, between 46 and 75 days of age, when both groups were eating only solid food, the intake of AR kids remained higher than that of TR kids (Table 3). This agrees with Ugur et al. [27] who stated that early weaned kids are more experienced in the consumption of solid feed, which provides them a significant advantage for their development. The metabolizable maintenance energy requirement calculated according to NRC [28] for the first 15 days after weaning was 2.15 MJ d^{-1} for AR kids (period between 31 and 45 days of age) and 2.54 MJ d^{-1} for TR kids (period between 46 and 60 days old). While for the same periods, metabolizable energy intake was 1.13 and 1.53 MJ d^{-1}, for AR and TR kids, respectively. These results indicate that although solid feed intake increased significantly after weaning, none of the two groups of kids covered their metabolizable energy requirements during the first 15 days after weaning. This can be attributed to the low voluntary intake of solid food that kid goats have in comparison with other domestic ruminants [26].

Weaning is a stressful period usually characterized by a decrease in growth performance because animals have to adapt to anatomical, physiological and metabolic changes that occur during the transition from lactating to ruminant [30]. Morand-Fehr et al. [31], argue that the earlier the weaning is performed, the more pronounced the weaning shock is. The weaning shock explains the lower bodyweight of AR kid goats compared to TR kid goats between 42 and 56 days of age. However, at 63 days of age, AR kid goats reached a similar bodyweight than TR kid goats, and no differences were observed between groups until end of the trial (Figure 1). Several authors [26,31-35] have reported this phenomenon in animals after a dietary restriction that adversely affected its growth. This "compensatory growth" is characterized by an increase in the rate of weight gain that allows restricted animals to reach the bodyweight of unrestrained animals. Probably AR kid goats experienced a great nutritional restriction due to the low voluntary intake of solid food after weaning and due to the anatomical and physiological changes involved in the transition to ruminant. The higher growth

rate of AR kid goats could be due to the higher consumption of solid food of these animals in comparison with TR kid goats [33,35].

Relationship between rumen content, microbial concentration and total number of microorganisms

The correlation coefficients obtained indicate that in kid goats at 21 and 30 days of age, the total number of microorganisms present in the rumen is determined both by microbial concentration and by rumen contents. This differs from that observed by Dehority et al. [15] in adult cattle, where the total number of microorganisms in the rumen is determined mainly by microbial concentration. Whereas from 45 days of age onwards, the total number of microorganisms in the rumen is mainly determined by microbial concentration, coinciding with what happens in adult animals with a fully developed rumen. Variations in total number of microorganisms present in the rumen of adult animals are mainly due to variations in microbial concentration, because the capacity of the rumen and its contents are less variable [15]. By contrary, in young animals size and capacity of the rumen increase as it develops [16]. The increased capacity and ruminal contents would produce a dilution effect of microbiota that decreases the microbial concentration thus leading to errors in the estimation of the total number of rumen microorganisms. These results indicate that in kid goats with a developing rumen it should be determined both rumen contents and microbial concentration to estimate the total number of microorganisms and to accurately assess changes in rumen microbial populations. For this reason, in this work, the total number of protozoa, anaerobic, amylolytic and cellulolytic bacteria was used to compare rumen microbial populations between groups of kids under different rearing systems.

Functional groups of rumen microorganisms according to age and rearing system

No differences were found with respect to age at which was first recorded each microbial populations. This shows that the rearing system did not affect either the sequence or the time in which functional groups of microorganisms were established in the rumen (Table 5). The absence of cellulolytic bacteria and protozoa at 21 and 30 days of age establish an important difference between microbial functional groups observed in young kids compared to those found in adult animals. Only after 45 days of age, microbial functional groups were similar to those of adult goats [14]. This agrees with Bryant et al. [12], who reported that the ruminal microbial population between the first and third week of life is different from adult animals. While between 9 and 17 weeks of age, microbial populations are similar to those of adult cattle.

In both groups, the anaerobic and amylolytic bacteria were present from 21 days of age, even though TR kid goats had not yet consumed solid food. This coincides with Minato et al. [36] and Anderson et al. [11] argue that in calves some bacteria colonize the rumen in the first days of life, even before the start of solid food intake. In kids of

both groups, cellulolytic bacteria were recorded from 45 days of age, long time after that reported in lambs [37] and calves [11,12], in which were found during the first week of life. Protozoa were also established at 45 days of age, earlier than observed in calves [11,36], but after than lambs [38]. Since 30 days of age, kid goats from both rearing systems began to consume a ration of alfalfa and corn (Table 3), incorporating more fiber in their diet (Table 2). Fiber intake increases chewing and rumination time which consequently stimulates the production of saliva and increases ruminal pH [39]. Fiber intake allows for the proliferation of cellulose degrading bacteria (cellulolytic) (Table 5). Furthermore, protozoa and cellulolytic bacteria are sensitive to low pH values (below 6.3) [2]. AR kid goats had low ruminal pH values at 21 and 30 days of age, which contributes to explaining why these microbial populations were not established until 45 days of age in the rumen.

The sequence of establishment of microbial functional groups in both rearing systems is consistent with that reported by Minato et al. [36], who argue that anaerobic and amylolytic bacteria are established in the first days of life. Cellulolytic bacteria establish later and protozoa appear ultimately, because are sensitive to low pH and therefore can establish when the bacterial fermentation is stable [6]. The higher counts of anaerobic and amylolytic bacteria observed in AR kid goats at 21 and 30 days of life could be attributed to early rumen starter intake (from 15 days of age in this group). The high proportion of easily fermentable carbohydrates in the rumen starter (331 g kg^{-1} starch on a dry matter basis) surely allowed the proliferation of a wide variety of rumen bacteria [5]. Furthermore, it has been reported that the income of small amounts of milk into the rumen can allow the growth of some facultative anaerobic bacteria such as *Lactobacillus* spp., which have been described as one of the main bacterial species in the rumen of suckling calves [11,40]. The low pH values recorded at 21 and 30 days of age are compatible with the proliferation of this type of bacteria [11]. According to Ørskov [41] lactic fermentation can cause a large decreases in ruminal pH selecting very specific microbial populations.

From 45 days of age onwards, no differences were found in the total number of different microbial functional groups (except for amylolytic at 45 days) between kids of both systems. This may be because TR kid goats began consuming the feed ration from 30 days of age. Which indicates that these animals in as little as 15 days, achieved similar amounts of ruminal bacteria and protozoa than that registered in AR kid goats, who had much more time to consume solid feeddstuff. These results agree with Poe et al. [42] and Anderson et al. [11], who found that consumption of solid food allows for development of rumen microbial activity in a few days. Ruminal pH reflects amount of volatile fatty acids (VFA) produced by bacteria during fermentation and is regulated by ruminal absorption of acids and by the buffering capacity of saliva [43,44]. The lower values of ruminal pH of AR kid goats at 21, 30 and 45 days old, may be attributed to a greater amount of amylolytic bacteria recorded in these animals and would indicate a greater microbial fermentation of rumen starter with an increased production of VFA. The subsequent increase in pH after 45 days of age and the

lack of differences between the two groups after 70 days of age onwards could be attributed to an increased absorption of VFA and a rise in rumination and salivation caused by intake of alfalfa hay [2].

These results allow the conclusion that in kid goats with a developing rumen the total number of microorganisms should be determined to accurately assess changes in rumen microbial populations. Furthermore, rearing system did not affect sequence and time in which functional groups of microorganisms were established in the rumen of kids. However, alternative rearing system with early intake of solid food allowed the establishment of greater amount of bacteria and protozoa in the rumen. Nevertheless, the effect of weaning on growth rate was more marked in kids from alternative rearing system, despite its greater microbiological development.

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UTICAJ SISTEMA UZGOJA NA USPOSTAVLJANJE RAZLIČITIH FUNKCIONALNIH GRUPA MIKROORGANIZAMA U BURAGU JARADI

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Ova studija je imala za cilj da utvrdi uticaj sistema uzgoja na uspostavljanje i razvoj različitih funkcionalnih grupa mikroorganizama u buragu jaradi. Pedeset jaradi je hranjeno kozjim mlekom do odbijanja 45-og dana (TR, tradicionalni sistem uzgoja, n= 25) i 30-og dana starosti (alternativni sistem uzgoja, AR n=25). Jarad iz AR grupe je dobijala rumen starter od rođenja.Obe grupe su konzumirale seno lucerke i mleveni kukuruz od 30-og do 90-tog dana starosti. Iz svake grupe je žrtvovano po 5 jaradi 21, 30, 70 i 90-tog dana starosti. Određivan je ukupan broj protozoa, anaerobnih, amilolitičkih i celulolitičkih bakterija prisutnih u buragu. Jarad iz AR grupe imali su manju telesnu težinu u odnosu na jarad iz TR grupe u periodu između 42. i 56. dana starosti. Kod jaradi iz oba sistema uzgoja 21. dana starosti su ustanovljene anaerobne i amilolitičke bakterije, dok celulolitičke bakterije i protozoe nisu ustanovljene sve do 45-tog dana starosti. Jarad iz AR grupe su imala veće količine anaerobnih i amilolitičkih bakterija do 30., odnosno 45. dana starosti. Ovi rezultati pokazuju da sistem uzgoja ne utiče na vreme i redosled uspostavljanja funkcionalnih grupa mikroorganizama u buragu. Međutim, alternativni sistem uzgoja, koji podrazumeva rani unos čvrste hrane, omogućava uspostavljanje većeg broja bakterija i protozoa. Ipak, efekat zalučenja na rast je bio izraženiji kod jaradi u alternativnom sistemu odgoja, uprkos značajnijem mikrobiološkom razvoju buraga.