Effect of the rearing system on financial returns from Murciano-Granadina breed goats

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Improving financial returns on goat flocks

Abstract

In dairy goats, the kid rearing system can have critical importance in financial returns. Commonly used criteria for the choice of rearing system are not always clear due to the high number of factors involved. The aim of this study was to quantify all those factors to facilitate decision making. So, the effect of two different kid rearing systems, mixed (MRS) and artificial (ARS), on milk yield, milk composition and somatic cell count (SCC), milk yield loss at weaning for MRS, kid growth and costs of the different traits on the financial returns in Murciano-Granadina breed goats was studied. Twenty-four goats per group were used. In the MRS, goats reared only one kid, which had free access to goat milk 24 h a day and were weaned at week 6 of lactation, whereas kids in the ARS were separated from their mothers at kidding and colostrum and artificially reared. In both systems, dams were machine-milked once a day throughout lactation and the records took place weekly. Potential milk yield was estimated according to the oxytocin method up to week 12 of lactation, and was similar for both rearing systems, although a 12.3 per cent drop in potential milk yield at weaning was observed for MRS. During the first 6 weeks of lactation, marketable milk was lower for dams in MRS compared to those in ARS (72.1 *versus* 113.0 l), but similar for the rest of the experiment (101.5 *versus* 99.4 l, respectively). Actual milk composition and SCC throughout the 12 weeks of lactation were unaffected by the rearing system. Artificial rearing system entailed an increment in production cost of 22.2 € per kid compared to the rearing by MRS. A similar economic return per goat and kid was obtained from ARS and MRS in this experiment, although, due to one herd's prolificacy of 1.8, the actual results would be 16.2 € per goat in favour of MRS. The real interest of this experiment may be

the possibility of extrapolation to different flocks with diverse levels of milk production, prolificacy and prices and costs for incomes and outputs, to estimate the production system that increases returns. In conclusion, the results showed an increase in the cost of € 22.2 per kid bred in the artificial rearing system, compared to the mixed rearing system, and a final return of 16.2 € per goat in favour of the mixed system.

Keywords*:* Rearing, inputs, outputs, financial returns, goats

Implications

The implications of this paper are economic, as the viability of goat dairy farms can be affected by the type of rearing system used. The factors involved are those linked to the effect of the rearing system on the average milk production level of the goats, the degree of milk production drop at weaning of the does that raise their kids, the prolificacy of the herd, the labour required and the cost and price of the different affected inputs and outputs. This work quantifies all these factors, allowing us to determine the most appropriate lactation rearing system for each farm and thus improve its returns.

Introduction

The mixed rearing system (MRS), which involves a suckling and milking period *post partum* and usually once-a-day milking (Gargoury *et al*., 1993), and the artificial rearing system (ARS), with exclusive milking from parturition (McKusick *et al*., 2001), are two customary systems for the production of ewe and goat milk in Spain (Peris *et al*., 1997; Delgado-Pertíñez *et al*., 2009a and 2009b). It is

76 commonly accepted that, in the former, lamb suckling significantly increases (29-
77 42%) the ewe's milk yield, compared with the milk yield obtained by ARS (Louca,
78 1972; McKusick *et al*., 2002), and that milk production drops by approximately 17
79 to 40% after weaning (Labussière, 1988; McKusick *et al*., 2002). So, a low milk
80 drop at weaning could maintain the MRS lactation curve above the one
81 corresponding to the ARS for the rest of the lactation. In goats, while Peris *et al.*
82 (1997) and Keskin (2002) found no differences in milk yield throughout lactation
83 between both management systems, Delgado-Pertíñez *et al*. (2009a and 2009b)
84 obtained a higher (24-32%) milk production up to weaning and Delgado-Pertíñez
85 *et al*. (2009*b*) a higher (17 %) milk production from weaning to the end of lactation
86 for MRS compared to ARS. On the other hand, for both sheep and goats in the
87 ARS, extra milk marketed from one mother during suckling period must
88 compensate for the potential higher costs in this period, which would be increased
89 by a greater prolificacy. So, some of the most important factors that determine
90 the economic interest of the production system depend on the average level of
91 milk yield of the flock/herd, the possible effect of the newborn suckling on the milk
92 yield, the level of milk yield drop at weaning and the prolificacy. It is hypothesised
93 that the weaning system affects potential economic returns on dairy goat flocks,
94 as the MRS could increase the milk yield and the amount sold after weaning,
95 while the ARS, although presumably it will incur higher costs during suckling
96 period, could also enable a higher amount of marketable milk during this period.
97 Therefore, the objectives of the present study were: 1) to evaluate the possible
98 effect of rearing one kid by MRS *versus* ARS on lactation curve and milk
99 composition; 2) to evaluate the milk drop that occurs at weaning in the MRS

system; and 3) to estimate the relative impact of MRS and ARS on economic returns in a herd of Murciano-Granadina breed goats.

Materials and Methods

Goats and General Procedures

Forty-eight multiparous (3 ± 0.4) Murciano-Granadina breed goats (45 ± 2 kg) were used at the experimental farm of the Universitat Politècnica de València (Spain). Mating was synchronised by intravaginal sponges (30 mg fluorogestone acetate) and 450 PMSG International Units (**IU**; Chrono-gest, CEVA Salud Animal, Spain) were injected, so that all births took place over a 14 day period. At parturition, goats were assigned randomly to an MRS (n = 24 goats), similar to that of Gargouri *et al*. (1993), or to an ARS (n = 24 goats), similar to McKusick *et al*. (2001**),** and with the same level of prolificacy in each group. In the MRS, each goat suckled one kid for 24 hours a day and was subjected to once-a-day milking (0800 h) for the entire lactation period studied (0-12 weeks *post partum*) and kids were weaned at 6 week of lactation. In the ARS, kids were separated from their dams at kidding and colostrum and artificially reared in straw-bedded pens (size = 0.3 m^2/kid; two bowl water troughs) from birth and goats were also milked once a day until 12 week of lactation. Kids were trained to suckle from a teat connected to a unit for feeding liquid diets (LAC-TEC, France). A commercial kid milk replacer (Nantamilk corderos y cabritos, NANTA, Spain) was given, reconstituted at 180 g milk replacer per litre of water, continuously mixed (half a litre each time) and offered *ad libitum* on a 24 h basis. Gross energy of reconstituted milk replacer and average potential goat milk at the suckling period (3.8 and 3.85 MJ/l, respectively) were analysed using an isoperibolic calorimeter (AC-500, LECO

125 Instruments, USA). Water was supplied *ad libitum* to kids. All adult goats received
126 the same mixed feed ration twice daily (0900 h and 1800 h), although both
127 experimental groups remained separated until the kids were weaned, whereupon
128 all goats were kept together in the same pen (size = 1.5 m^2/goat; feeder = 0.5
129 m/goat; five bowl water troughs). The ration was formulated according to Sauvant
130 *et al*. (2007) and consisted of: 1) a basal diet to meet minimum recommendations
131 for maintenance plus 1.0 l milk/day (8.71 MJ net energy; 99 g metabolisable
132 protein; 8.7 g Ca; 4.9 g P) including alfalfa hay (30% as DM), barley straw (26%),
133 beetroot pulp (18%), orange pulp (26%), and 2) a commercial concentrate for
134 dairy goats (6.78 MJ net energy, 135 g metabolisable protein, 9 g Ca and 4 g P
135 per kg of DM) to meet a total average milk yield of 3.3 and 2.6 l milk per goat per
136 day, at different stages of the lactation curve. Rations were offered to the dams
137 in an amount 10% higher than the calculated voluntary feed intake. Throughout
138 the experimental period, in the MRS pens, feeders were arranged so that the kids
139 had no access to the feed provided to the dams, and therefore the only source of
140 nutrients available to the kids was maternal milk. A high line Casse type milking
141 parlour (two platforms; 12 ewes per platform; six milking units) was used;
142 machine milking parameters were set to: vacuum = 40 kilopascals, pulsator rate
143 = 90 cycles per minute and pulsator ratio = 66%. Does were machine-milked
144 without any udder preparation and using the following routine: machine milking
145 (MM), machine stripping (MS) and post-milking teat-dipping (Proactive Plus.
146 0.15% iodine, 4% glycerine, and 4% sorbitol-based emollient, DeLaval, Spain).
147 Machine stripping involved a vigorous udder massage for 15-20 seconds just
148 before the teatcups were removed. The terms pre- and post-weaning were used
149 to describe the stages of lactation: days 1 to 42 and 43 to 84, respectively. Milk

production and composition for the stages of lactation were calculated based on weekly testing. Kids were weighed at birth and weekly thereafter until weaning from their dams (MRS kids) or from the milk replacer (ARS kids), and adjusted 42 day weights were calculated.

Experimental Data and Sample Collection

Marketable milk yield was recorded once a week at 0800 h on Tuesday. Separate measurements were recorded of the milk obtained by unassisted milking (MM) and MS. Immediately afterwards, potential milk yield was determined according to the double oxytocin injection method (McCance, 1959; Doney *et al*., 1979). Goats were injected twice with 3 IU of oxytocin (Hormonipra; Laboratorios Hipra, Spain) into the jugular vein, with a 4 h time interval between injections. After the first injection, the udder was emptied by machine to obtain residual milk and the milk volume obtained after the second injection was multiplied by a number in proportion to the exact time interval between milkings, to obtain 24 hour production (potential milk; Doney *et al*., 1979). Samples (50 ml) of marketable (MM + MS) milk were collected and immediately analysed for milk composition and somatic cell count (SCC). Milk composition (fat and protein) was analysed with an infrared analyser (Milkoscan FT6000; Foss Iberia, Spain) and SCC was determined by the fluoro-opto-electronic method (ISO, 2008; Fossomatic 5000, Foss Iberia, Spain). Instruments were calibrated with milk standards for more reliable and accurate analyses. Milk yield was expressed as fat corrected milk (FCM) at 3.5% fat milk using the equation proposed by Sauvant *et al*. (2007) for goats [FCM yield = milk yield x (1 + (0.0075 x g/l fat – 35/0.4))]. On record days, the kids suckled until the time of daily milking (0800 h) and after 1600 h.

Attributable costs

For economic comparisons of the rearing systems, calculations were based on the production of one goat and her only kid, taking into account only differential costs between systems. The average price received for commercial milk and for live kid marketed at 42 day of age was 0.85 €/l and 6 €/kg live weight, respectively. For the calculation of the labour occupation during rearing period, the times used by the workers in the specific tasks were noted every day, and the total time dedicated to each one was divided among the corresponding number of kids. The extra expenses for the MRS goats compared to ARS goats included extra labour to separate kids from the dams once per day for 42 days (7.9 min/day per group at 9.0 €/h) and extra feeding to maintain the same body condition (230.9 *versus* 218.0 = 12.9 l). The extra expenses for the ARS kids compared to the MRS kids included milk replacer (9.5 kg/kid at 2.51 €/kg), labour for kid assistance and machine handling, maintenance, machine depreciation and supplies (electricity, water). The kids consumed only milk (natural or artificial, according to the group).

Statistical analysis of results

Separately for each rearing system (ARS or MRS), the evolution of milk produced per goat on the record days was statistically analysed with a repeated measures model that included the fixed effects of milk evaluation type (marketable or potential), week of lactation and their interaction, the random effect of animal and residual error. When an interaction was non-significant ($P > 0.05$), the corresponding interaction term was pooled with the error. These models were analysed by a mixed model (MIXED procedure; SAS, 2011). The total marketable and total potential milk yield produced, as well as the average milk composition and SCC belonging to the pre-weaning, post-weaning and global lactation, were

analysed statistically using a model (model two) that included the fixed effect of rearing system and residual error. The SCC logarithm (SCClog) was used to normalise SCC distribution (Ali and Shook, 1980). Kid growth and weaning weight were analysed with a model (model three**)** that included the fixed effect of rearing system and birth weight as covariant. The GLM procedure (SAS, 2011) was used with models two and three. For all models, separation of the means for the determination of a significant ($P < 0.05$) main effect was performed using pairwise contrasts (PDIFF option from SAS, 2011).

Results

Lactation pattern, milk yield and composition

Figure 1 shows least square means of daily milk yield evolution for goats under MRS (n = 24) and ARS (n = 24). Four curves corresponding to MRS potential milk, MRS actual milk, ARS potential milk and ARS actual milk are described. For ARS, there were no significant effects of type of milk evaluation or interaction between the milk evaluation type and week of lactation ($P = 0.9921$).

For MRS, interaction (type of milk evaluation*week of lactation) was significant ($P < 0.001$), as significant differences were found between actual and potential milk for all weeks from the pre-weaning period ($P < 0.001$), but only for the first week post-weaning ($P = 0.041$). A drop of 367 ml (12.3%) and 148 ml (5.5%) was observed in potential milk yield between weeks 6 and 7 for MRS and ARS, respectively. When all the lactation was taken as a whole (Table 1), differences in total potential milk yield between systems were non-significant ($P = 0.096$). Likewise, neither differences for total potential milk yield ($P = 0.081$) during the pre-weaning term, nor over the post-weaning period ($P = 0.345$), were found

between systems. Significantly ($P < 0.001$) more marketable milk is produced when kids are artificially reared from kidding than when suckling (weeks 0-6). However, after weaning no significant differences were observed ($P = 0.577$) for marketable milk between ARS and MRS (weeks 7-12). Milk composition (fat, protein) and SCClog in milk were similar for dams in MRS and ARS for all weeks of lactation (Table 1).

Insert Figure 1 and Table 1

Kid growth

One kid per system died during the trial. Table 2 shows the kid's average daily weight gain and live weight at 42 day depending on the rearing system. Rearing system affected significantly ($P = 0.035$) live weight at 42 day but not average daily gain ($P = 0.113$). Taking into account that, during rearing phase, potential milk overestimates 3.3% of actual milk for ARS, the real milk production for MRS goats would be 3.3% less than 125.6 l (121.46 l) during this phase. Thus, the difference between potential and marketable milk until weaning for MRS (49.3 l) indicates that each kid suckled an average of 1.17 l/day, while the average consumption of kids from ARS was 1.24 l/day. So, during the rearing period, estimated average total gross energy per kid was 189.2 and 197.9 MJ for MRS and ARS, respectively.

Insert Table 2

Economic analyses

A total of 6.5 and 28.7 € of differential costs (Table 3) during the 6 weeks post-kidding, and a total income of 204.4 and 228.2 € (Table 4) were computed for

MRS and ARS, respectively. So, economic returns of 197.9 and 199.5 € were obtained for MRS and ARS, respectively.

Insert Table 3 and Table 4

Discussion

The milk yield finding agrees with the figures reported by Peris *et al*. (1997), but disagrees with Delgado-Pertíñez *et al*. (2009a and 2009b), who found differences between MRS and ARS for any lactation period. The different results observed could be due to the fact that, for Delgado-Pertíñez *et al.* (2009a and 2009b), the goats under MRS increased their potential milk production by 24% and 32%, respectively, compared to the goats under ARS, while that increase was much lower for Peris *et al.* (1997) (1.1%) and for this work (7.4%), and that the two milkings per day after weaning allowed goats under MRS to maintain an advantage of 17% in milk production over ARS from weaning to the end of lactation."

The fact that in this experiment kid suckling did not significantly increase potential milk yield compared to an ARS management also contrasts with what usually happens in ewes according to Labussière *et al*. (1974) and McKusick *et al*. (2002), who demonstrated the importance of a low milk yield drop at weaning that would allow them to maintain a higher lactation curve pattern throughout the rest of lactation and so improve economic returns for the MRS. After weaning, MRS marketable and potential milk yield were different only for the first week (week 7; Figure 1), which seems to show a certain inhibition of milk reflection reflex and a significant retention of milk in the udder at weaning, as found by Marnet and

Negrão (2000) and McKusick *et al*. (2001) in ewes. Milk retention may slow down cell secretion activity by the accumulation of autocrine regulators of milk secretion, such as feedback inhibitor of lactation (Rennison *et al*., 1993; Peaker and Wilde, 1996). On the other hand, Stull *et al*. (2007) proposed that serotonin alters barrier function and dissipates the transepithelial gradients necessary for milk secretion, thus acting as an inhibitor. On the contrary, Silanikove *et al*. (2006) and Silanikove *et al*. (2010) proposed that a lower milk volume in upper parts of the udder dilute the content of β-CN *f*(1-28), which in turn reduces the inhibition of fluid secretion**.** All these explanations indicate that milk retention in the upper parts of the udder entails, among other things, a lower milk secretion at weaning, as occurred in ewes.

Our observation regarding the similar milk fat composition during pre- weaning period for MRS and ARS does not agree with those reported by Eik *et al*. (1999) in goats or by Gargouri *et al*. (1993) and Requena *et al*. (2010) in ewes, who found a lower commercial milk fat content for MRS during the partial suckling period. This difference may be due to the management performed, as in this experiment the kids stayed with their mothers until milking time, while in the other cases they were separated some hours before going up to the milking parlour. Requena *et al*. (1999) showed that the low fat milk obtained during early lactation from ewes under MRS could be one of the major concerns for cheese-processing facilities.

Average birth weight (2.43 kg) was similar to the results of Pérez-Baena *et al*. (2013) and lower than those of Sanz (2005) for the same breed (2.46 kg and 2.7 kg, respectively). In terms of average daily gain, Sanz (2005) found significant differences between systems (169 *versus* 118 g/day for MRS and ARS,

299 respectively), and Pérez-Baena *et al*. (2013) also obtained higher values for MRS
300 compared to ARS (151 g/day *versus* 128 g/day, respectively), using the same
301 facilities as in this experiment but in a bucket rearing system. Growth essentially
302 depends on the ingested energy, and so the higher growth of MRS kids from this
303 experiment may be explained because although the estimated ingested gross
304 energy per kid was slightly higher for ARS, goat's milk usually has higher
305 digestibility (Sanz *et al*., 1990), and the possible effect of growth promoters on
306 milk in goats, as well as what was observed in cattle by Baumrucker and Blum
307 (1993).
308 A similar economic return per goat and kid from ARS and MRS was obtained in
309 this experiment, as the extra commercial milk achieved using ARS and the price
310 applied more or less exactly compensated for the extra costs of artificial rearing
311 compared to MRS. However, as the herd's prolificacy is 1.8, the actual results
312 would be 16.2 € per goat in favour of MRS.
313 In conclusion, ARS entailed an increment of 22.2 € in rearing production cost of
314 kids compared to the MRS. A similar economic return per goat and kid was
315 obtained from ARS and MRS in this experiment, although, due to one herd's
316 prolificacy of 1.8, the actual results would be 16.2 € per goat in favour of MRS.
317 Beyond the results in a given flock, the real interest of this experiment may be
318 the producer's possibility of extrapolation to different levels of milk production,
319 prolificacy, and prices and costs for incomes and outputs, to estimate the weaning
320 system that increases returns in a specific situation.
321
322 **Ethics**

Housing and handling of the experimental animals followed the mandatory principles for care and use of experimental animals in Spain (Real Decreto 53/2013, Boletín Oficial del Estado 34, 11370-11421).

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Table 1. *Least square means (± SEM) for lactation traits of Murciano-Granadina goats under mixed rearing system (MRS) or artificial rearing system (ARS)*

Trait	Rearing system		SEM	*P-value*
	MRS (n = 24)	ARS (n = 24)		
Potential milk yield, l per goat and period				
weeks 0-6	125.6	116.9	4.5	0.081
weeks 7-12	105.9	101.7	3.5	0.345
Total	230.9	218.0	7.5	0.096
Marketable milk yield, l per goat and period				
weeks 0-6	72.1	113.0	3.5	< 0.001
weeks 7-12	101.5	99.4	3.2	0.577
Total	173.1	206.0	5.9	< 0.001
Milk fat, g/kg				
weeks 0-6	55.9	58.4	2.3	0.454
weeks 7-12	49.5	48.6	2.0	0.746
Milk protein, g/kg				
weeks 0-6	33.2	35.0	1.1	0.278
weeks 7-12	32.8	34.4	1.2	0.369
SCC, log				
weeks 0-6	5.88	5.77	0.10	0.363
weeks 7-12	5.57	5.64	0.09	0.335

Table 2. *Least square means (± SEM) for kid growth traits under mixed rearing system (MRS) or artificial rearing system (ARS)*

Trait	MRS (n = 23)	ARS (n = 23)	SEM	*P*-value
Birth weight, kg	2.42	2.44	0.08	0.093
ADG[1] , g/day	169	153	15	0.113
42 day weight, kg	9.55	8.85	0.21	0.035

[1]ADG = Average daily gain from birth to 42 days of age

Table 3. *Time employed on the different tasks and differential costs per kid during rearing phase (0-6 weeks) under mixed rearing system (MRS) or artificial rearing system (ARS)*

	Time (h/42 day)		Differential costs (€)			
Rearing system	Kid[1]	Machine handling[2]	Feed[3]	Labour[4]	Others[5]	Total
MRS	0.23	-	4.4	2.1	-	6.5
ARS	0.13	0.28	23.8	3.7	1.2	28.7

[1]Kid assistance and separating kids from their mothers

[2]Milk replacer machine

[3]Milk replacer for ARS and the extra feeding to compensate extra milk production for MRS

[4]Labour costs for kid assistance and machine handling

[5]Electricity, water, machine cleaning

Table 4. *Differential economic returns for mixed rearing system (MRS) and artificial rearing system (ARS) with Murciano-Granadina goat breed*

Rearing system	Differential costs[1] (€)	Income (€)			Economic return (€)
		Meat	Milk	Total	
MRS	6.5	57.3	147.1	204.4	197.9
ARS	28.7	53.1	175.1	228.2	199.5

[1]Differential costs for the suckling period and the maintenance of goat body condition score due to the higher total milk produced by the MRS.

501

502 **Figure 1.** Least square means (± SEM) of daily milk yield evolution for Murciano-
503 Granadina goats under mixed rearing system (MRS= 24) and artificial rearing system
504 (ARS= 24). *** Indicates a significant difference ($P < 0.001$) for the whole pre-weaning
505 period, while * indicates a significant difference ($P < 0.05$) at 7th week between MRS
506 potential milk and MRS actual milk

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