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Effect of early nutrition on carcass and meat quality of young goats under milk production systems

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14.1. Abstract

Goat kids in intensive dairy goat farms are usually reared on milk replacers, due to farmers' desire to use all the milk for commercial purposes or cheese-making. In this chapter, growth, carcass and meat quality characteristics of goat kids fed milk replacers are studied in depth in comparison with kids reared naturally on goat milk.

14.2. Introduction

Different management methods have been proposed for goat kid rearing on dairy goat farms. These include natural suckling (NS), restricted natural suckling (RNS), ad libitum artificial rearing (ALAR) on milk replacers and restricted artificial rearing (RAR). These are summarized as follows:

- The NS system implies that kids remain with their dams from birth until the end of the suckling period with free access to goat milk 24 h a day.
- RNS is a system in which kids have access to their dams for a limited period of time per day.
- ALAR implies that kids are hand-fed colostrum during the first 2 days after birth. After the colostrums feeding period, the kids usually are accommodated in artificial rearing pens with at least 0.3 m^2 floor space per kid. Centrally heated pens have a temperature of around 20ºC. The animals are trained to suckle from an artificial teat fitted to a unit for feeding liquid diets. The milk replacer is continuously mixed and offered ad libitum on a 24 h basis.
- Under the RAR system, kids are reared as for the ALAR group except that milk replacers are made available twice a day for a limited period of time.

Goat milk and milk replacers differ in composition. The protein source of milk replacers is often milk protein concentrates and whey proteins (Beserra *et al*., 2003). The casein content of milk replacers is lower than in goat milk, which may produce some problems with curd formation in the kid abomasum (Sanz Sampelayo *et al*., 1990). Hashimoto *et al*. (2007) included soy as a protein source in milk replacers, but the effects on growth and meat quality are yet to be clearly defined. Carbohydrates are higher in milk replacers due to the overall lactose content. The main raw components in milk replacers are cow skimmed milk and cheese whey, and both are very rich in lactose. A high lactose content in milk replacers has been related to osmotic diarrhoea in kids (Argüello *et al*., 1999). Some experiments have been carried out using starch as a raw material in milk replacers (Nitsan *et al*., 1990), but diarrhoea was a major problem. A major difference in chemical composition between goat milk and milk replacers is also the fat source. Milk replacers are based on cow skimmed milk and cheese whey, and both ingredients have a low fat content. Therefore, vegetable fats are added to milk replacers as the main fat source. These include mainly palm or coconut oils. Bañón *et al*. (2006) recently reported substantial differences in fatty acid composition between goat milk and milk replacers. The main fatty acids in goat milk are C16:0 (30%), C18:1 (22%) and C18:0 (14%), whereas in milk replacers they are C12:0 (29%), C16:0 (23%) and C18:1 (16%). New advances in milk replacer formulations are currently under way. Tacchini *et al*. (2006) reduced the use of cow milk to 15%, and our group is introducing seaweed into formulations with encouraging preliminary results.

14.3. Goat kid growth under goat milk or milk replacer diets

The goat is an important source of meat in Africa, Asia and the Far East. It is now emerging as an alternative and attractive source of meat in other parts of the world. With milk goat breeds, kids are usually reared on milk replacers, so that all milk produced can be sold as fresh milk or processed into dairy products as cheese or yogurt. Young kids have to be routinely fed milk replacers.

14.3.1. Growth curves

Growth in farm animals in general, and goats in particular, is usually represented by an exponential curve. However, observations during the first month of life have shown a better statistical fit to a linear regression (Argüello *et al*., 2004).

Growth curves of kids reared during the first month of life under NS, ALAR and RAR systems are shown in Fig. 14.1 (Argüello *et al*., 2004). NS kids have a significantly higher average daily gain (ADG) than ALAR and RAR kids (Pérez *et al*., 2001; Argüello *et al*., 2004), and ALAR kids have a significantly higher ADG than RAR kids (Argüello *et al*. 2004). The higher ADG in NS kids is caused by the higher digestibility of components in goat milk than in milk replacers because the goat milk curd stays longer in the abomasum than the milk replacer curd (Sanz Sampelayo *et al*., 1990; Baumrucker and Blum, 1993). Baumrucker and Blum (1993) found that dams' milk has a growth promoter that is not present in milk replacers, which could explain the higher ADG in NS kids. NS kids growth rates ranged from 140 to 200 g/day in different breeds such as Majorera (Argüello *et al*., 2004), Verata (Fariña *et al*., 1989) and Damascus (Louca *et al*., 1977). Some authors have attributed the higher growth rate to a higher feed intake capacity in kids raised ad libitum (Sanz Sampelayo *et al*., 1987; Yan *et al*., 1993).

Fig. 14.1 near here.

There are many factors that affect growth curves of farm animals, including birth weight, feed conversion efficiency and RNS, each of which is discussed in more detail.

Birth weight

Birth weight has an important effect on the first month's growth pattern for goat kids (Argüello *et al*., 2004). Table 14.1 shows the results for Majorera goat kids where the Pearson correlation coefficients between birth weight and weight at *n* days were statistically significant ($P < 0.01$) throughout the first 28 days of life for all groups. While the significance of the correlation coefficients observed with the ALAR and RAR methods lasted throughout the whole experiment, in the NS method the correlation lasted only until day 28. This behaviour is the opposite of what we expected, as the constant availability of food should have minimized the effect of birth weight.

Table 14.1 near here.

Feed conversion efficiency

From a financial point of view, it is also necessary to evaluate the feed conversion efficiency (FCE), which is a measure of an animal's efficiency in converting feed mass into increased body mass. Argüello (2000) reported similar FCEs for both male and female animals, with higher FCE values observed at the beginning of the experiment compared with the final period (Fig. 14.2). Tejón *et al*. (1995) reported FCE levels of 1060.19 and 1115.11 g/kg for males and females, respectively, in Guadarrama goat kids reared by artificial rearing for 0–21 days. The differences displayed between initial and final FCE levels are probably due to the lesser development of the digestive tract in kids at an early age. This becomes more evident in terms of milk assimilation and transformation as the animal grows older. The results obtained for FCE in males and females indicate that females are more efficient in terms of milk replacer transformation. Nevertheless, such differences are slight and are probably due to the greater voracity of males, which makes them tend to consume greater amounts of feed regardless of age.

Fig. 14.2 near here.

Restricted natural suckling

In special circumstances, kids are reared under RNS management. When the milk is highly valuable, farmers try to minimize the amount of milk used for feeding kids and allow the kids to access their mothers for only a few hours a day. This system of management reduces the ADG in kids (Genandoy *et al*., 2002) compared with NS management due to the lower milk intake. Therefore, RNS is not an adequate management system for meat production and must be recommended only when milk has a high price.

14.4. Effect of the diet (goat milk or milk replacers) on kid carcass quality

Goats are ruminant animals that produce useful products such as fibre, meat, milk and leather. In some regions of the world such as southern Europe, goats have been selected primarily for milk production (Harvey and Rigg, 1964). In such systems, few goats are raised for meat production as the major selection criterion in regions where milk production is the primary focus. Kid carcasses from dairy goats have little fat (Kirton, 1988). Traditionally, in non-specialized dairy goat herds, goat kids are reared with their dams, which results in reduced milk yield and thus less milk for cheese manufacturing. Therefore, goat keepers remove the kids from their dams very early post-natally (15 days of age; 5–6 kg live weight). These kids are then harvested for meat. Unfortunately, carcasses from these kids are very light in weight (~3 kg) and therefore have little saleable meat. Furthermore, consumers in Mediterranean countries and others regions (e.g. Canary Islands) prefer meat from kids that have only been fed milk. All these factors contribute to the production of a very light live weight of kids at slaughter and carcasses with low meat quality and yield, resulting in goat keepers not earning significant financial profits.

14.4.1. Body weight, carcass yield and offal

Losses in goat kid carcasses due to chilling are not affected by diet (goat milk vs milk replacers) according to Argüello *et al*. (2007). In reference to carcass yield, some authors (Argüello *et al*., 2007) did not observe differences between animals fed goat milk or milk replacers due to lack of differences in nutritive characteristics between diets. Table 14.2 shows weights and carcass yield in goat kids fed goat milk or milk replacers (Argüello *et al*., 2007).

Table 14.2 near here

Argüello *et al*. (2007) studied the influence of diet on offal components in kids (Table 14.3). There were no significant effect of diet on the percentage of blood, skin, feet, gastrointestinal tract full and empty, gastrointestinal content, liver, urinary bladder, testicle plus penis, spleen, head, lungs plus trachea, heart and thymus of the live weight at slaughter. However, the weight of the right kidney was significantly higher in kids fed with milk replacers.

Table 14.3 near here

14.4.2. Carcass conformation

Argüello *et al*. (2007) studied carcass conformation measurements and indices in Majorera goat kids fed goat milk or milk replacers. These included: width between hips (G), depth at 6th rib (Th), carcass length (L), leg length (F), chest width (Wr), hips perimeter (B), long leg compact indices (G/F and B/F), cold carcass weight (CCW) and carcass compactness index (CCW/L) (Table 14.4 and Fig. 14.3). These authors found differences ($P < 0.01$) between diets for L and F measurements. Rearing in small pens (milk replacer diet) could be the reason for these little differences found between kids on different diets. There were no significant differences between diets in G, WR, B and TH measures and CCW/L, G/F and B/F indices. There were significant interactions between diet and live weight at slaughter for L and F measures and CCW/L, G/F and B/F indices. When kids' live weight at slaughter was 6 kg, higher CCW/L values in kids on the milk replacer were found, due to these animals being older.

Table 14.4 near here.

Fig. 14.3 near here.

14.4.3. Primal cut distribution

Some authors (Argüello *et al*., 2007) found no differences in primal cut distribution in kids fed goat milk or milk replacers (Table 14.5). However, Sanz Sampelayo *et al*. (1985) found differences in lumbar rib percentages (~2%) between kids fed goat milk and kids fed milk replacers. These differences were probably a result of using different carcass jointing procedures.

Table 14.5 near here

14.4.4. Tissue composition

Argüello *et al*. (2007) studied the effect of diet (goat milk vs milk replacers) on tissue composition of kid carcasses (Table 14.6). There were significant effects of diet on subcutaneous, intermuscular and total fat in carcass and ribs, with the differences being higher in animals fed goat milk. Shoulder, long leg and flanks had lower percentages of intermuscular and total fat in kids fed milk replacers. There were no differences in fat content in neck. Morand-Fehr *et al*. (1986) previously reported similar results. They attributed this to a higher amount of fat fed in the NS system than in kids fed with milk replacers. The carcass total fat contents were lower than those reported by Gutiérrez *et al*. (1995) but were closer to those obtained by Colomer-Rocher *et al*. (1992). In the same breed, Argüello *et al*. (1997a,b,c) found that, while the amount of milk replacers increased, the total carcass fat percentage also increased. The bone and muscle tissue percentages did not differ as a result of diet.

Table 14.6 near here.

14.5. Effect of diet (goat milk or milk replacers) on kid meat quality

The goat population in the world comprises four major types of goat: fibre goats (e.g. angora, cashmere), dairy goats (e.g. Saanen, Toggenburg and Nubian), meat goats (e.g. Boer) and feral goats (Naudé and Hofmeyr, 1981). The world's goat population was around 870 million in 2009, with annual meat production of around 4.9 million tonnes (FAOSTAT, 2010). Consumers' preference for goat meat varies around the world. For instance, in India, the local community specifically seeks meat from mature goats, whereas in France and Latin America, meat from young milk-fed kids is considered a traditional delicacy. The acceptability of meat is greatly influenced by local custom and preference, so it is not possible to apply a universal standard for the quality of goat meat (Naudé and Hofmeyr, 1981).

14.5.1. Physical attributes

Physical attributes of meat quality include: pH, colour, tenderness and water-holding capacity. Some authors have studied the effect of diet (goat milk or milk replacers) on the meat quality of young goats (Argüello *et al*., 2005; Bañón *et al*, 2006). They did not find significant effects of diet on pH value or lightness, except for some slight differences in chroma values (a less intense red colour) (Tables 14.7, 14.8 and 14.9). Meat tenderness is considered one of the most important attributes in terms of consumer satisfaction. Diet significantly affected shear force values in the semimembranosus and triceps brachii muscles (Tables 14.8 and 9) with animals fed milk replacers having greater shear force values than animals fed goat milk. A similar trend was also observed for the longissimus dorsi muscle. These differences could be attributed to the fact that the animals were older and had consumed greater amounts of starter feed. This is in agreement with reports by Pisula *et al*. (1994), who found statistical differences between kids slaughtered at 16 kg live weight and exclusively fed milk replacers and those that had consumed starter feed (35.7 vs 42.6 N, respectively). The values obtained for water-holding capacity ranged between 0.31 g (6.2%) and 0.72 g (14.4%). The pH value and protein content play a fundamental role in the greater levels of expelled juice in animals fed goat milk (Argüello *et al*., 2005). The average pH value for animals fed goat milk replacers after chilling was 5.65, while kids receiving milk replacers had an average pH value of 5.70.

Table 14.7 near here
Table 14.8 near here
Table 14.9 near here

14.5.2. Chemical composition and muscle characteristics

Argüello *et al*. (2005) reported protein values of ~17–20% in goat kids, which resembles that of very young animals, as well as low muscle fat (0.84–1.26%). Fat is a late-growing body tissue, and in goats it is deposited in the more viscera than in other animals (Chilliard *et al*., 1981). The type of diet did not have a significant effect on the chemical composition of kid carcasses (Argüello *et al*., 2005). This is in accordance with the observations of Mueller *et al*. (1985) using kids of similar weights and feed types. In contrast, Bañón *et al*. (2006) reported higher moisture in kids fed goat milk or milk replacers (77 and 76%, respectively) and less protein in kids fed milk replacers. Collagen percentages and solubility were not affected by diet (Argüello *et al*., 2005; Bañón *et al*., 2006). Diet did not affect muscle fibre areas (Tables 14.7, 14.8 and 14.9), following the muscle fibre classification of Argüello *et al*. (2001).

14.5.3. Fatty acid percentages

Bañón *et al*. (2006) investigated diet effects on fatty acid composition in perirenal fat. The major fatty acids were C18:1, C16:0 and C18:0. These authors reported higher percentages in goat milk-fed kids than in artificially reared kids for the fatty acids C10:0, C14:0, C15:0, C16:0 and C18:0. In contrast, the goat milk-fed kids had lower values of C12:0, C16:1, C17:0, C18:1, C18:2, C18:3, C20:0 and C:20:4. The main fatty acids in kids receiving goat milk were C16:0, C18:1 and C14:0, and the ratio of saturated:unsaturated fatty acids was 2.27. In animals receiving milk replacers, the main fatty acids were C18:1, C16:0 and C18:0, and the saturated:unsaturated ratio was 0.94. Together with previous results, Bañón *et al*. (2006) thus demonstrated a strong effect of diet on fatty acid content.

14.5.4. Sensorial quality

Bañón *et al*. (2006) observed that the goat milk or milk replacer diet had pronounced effects on the sensory quality of cooked meat. The milk replacer diet gave cooked meat a more intense characteristic odour and flavour, more tenderness and increased juiciness.

14.6. Conclusions

Rearing goat kids with milk replacers has significant repercussions on their growth, carcass and meat quality. Goat kids fed milk replacers grow at a slower rate and have leaner carcasses than kids fed goat milk. The meat from kids fed milk replacers is characterized by a more intense colour. Substantial differences have also been reported in fatty acid profile. However, although the kids produced using the two diets differ, rearing goat kids on intensive dairy goat farms on milk replacers is more profitable if there is large enough price margin between goat milk and milk replacers.

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Fig. 14.1. Growth curves of goat kids raised under different feeding management systems (Argüello *et al*., 2004). NS, natural suckling; ALAR, ad libitum artificial rearing; RAR, restricted artificial rearing.

Fig. 14.2. Male (a) and female (b) goat kid feed conversion efficiency (efficiency of conversion of feed mass (kg) into increased body mass (kg) under the ad libitum artificial rearing method (Argüello, 2000).

Fig. 14.3. Principal measurement in kid carcass. G, Width between hips; Th, depth at 6th rib; L, carcass length; F, leg length; Wr, chest width; B, hips perimeter.

Table 14.1. Correlation matrix for birth and live weights of kids at different ages, as influenced by rearing methods (Argüello *et al*., 2004).

	Birth weight			
Weight at	NS	ALAR	RAR	NS+ALAR+RAR
7 days	0.92**	0.79**	0.90**	0.78**
14 days	0.73**	0.73**	0.76**	0.64**
21 days	0.83**	0.68**	0.65**	0.60**
28 days	0.73**	0.60**	0.62**	0.52**
35 days	ns	0.54**	0.55**	0.39**

NS. Natural suckling. ALAR. *Ad libitum* artificial rearing. RAR. Restricted artificial rearing. ** $P<0.01$. ns. No significant differences.

Table 14.2. Carcass yield parameters from kids fed milk or milk replacers (Argüello *et al*., 2007).

	Goat milk	Milk replacers	Standard error
Number of animals	20	20	
Live weight slaughter (kg)	8.31	8.10	0.33
Empty body weight (kg)	5.89	5.91	0.31
Hot carcass weight (kg)	2.97	3.01	0.18
Cold carcass weight (kg)	2.87	2.75	0.18
Chilling losses (%)	3.45	3.29	0.16
Net carcass yield (%)*	50.43	50.23	0.39

**(Hot Carcass Weight/Empty Body Weight) x 100

Table 14.3. Offal (% of live weight at slaughter) in kids fed milk or milk replacers (Argüello *et al*., 2007).

	Goat milk	Milk replacers	Standard error
Blood	3.89	3.27	0.14
Skin	10.18	9.93	0.01
Feet	3.85	4.09	0.10
GI tract (full)	14.57	15.33	0.49
GI tract (empty)	8.95	8.99	0.15
GI content	5.62	6.34	0.41
Liver	2.95	2.73	0.01
Urinary bladder	0.48	0.24	0.01
Testicle and penis	0.24	0.26	0.01
Spleen	0.22	0.21	0.01
Right kidney	0.33[a]	0.44[b]	0.01
Head	8.09	8.87	0.16
Lungs + trachea	1.72	1.69	0.01
Heart	0.75	0.68	0.01
Thymus	0.54	0.57	0.01

Values with different letters on the same row are statistically different.
GI, Gastric intestinal

Table 14.4. Carcass conformation and indexes from kids fed with different diets (Argüello *et al*., 2007).

	Goat milk	Milk replacers	Standard error
F (cm)	24.42[a]	23.13[b]	0.22
L (cm)	42.71[a]	40.48[b]	0.04
G (cm)	9.88	10.20	0.13
Wr (cm)	11.77	10.61	0.09
B (cm)	33.08	31.94	0.15
Th (cm)	16.79	16.84	0.14
CCW/L	93.55	93.16	0.21
G/F	0.41	0.44	0.01
B/F	1.36	1.38	0.01

Values with different letters on the same row are statistically different. G, width between hips. Th, depth at 6th rib. L, carcass length. F, leg length. Wr, chest width. B, hips perimeter. CCW/L, carcass compactness index. G/F and B/F, long leg compact index. CCW, Cold carcass weights.

Table 14.5. Contribution of organs and primal cuts to the carcass from kids fed dam milk or milk replacers (Argüello *et al*., 2007).

	Goat milk	Milk replacers	Standard error
Left kidney	1.32	1.44	0.01
Kidney and pelvic fat	2.95	2.62	0.14
Tail	0.50	0.39	0.01
Shoulder	20.85	20.76	0.24
Neck	10.09	10.80	0.26
Long leg	32.93	33.86	0.39
Flank	9.64	9.54	0.20
Ribs	21.64	21.33	0.36
By categories			
Extra	54.58	55.20	0.45
First	20.85	20.76	0.24
Second	19.73	20.34	0.30

Table 14.6. Proportions of fat, bone, muscle and primal cuts [1] of kids fed goat milk or milk replacers (Argüello *et al*., 2007).

		Goat milk	Milk replacers	Standard error
Carcass[1]	Subcutaneous fat	4.69[a]	3.79[b]	0.20
	Intermuscular fat	3.71[a]	2.56[b]	0.22
	Total fat	11.35[a]	8.97[b]	0.46
	Bone	29.43	30.32	0.45
	Muscle	55.03	55.70	0.46
	Losses	1.08	2.31	0.26
Shoulder	Subcutaneous fat	3.20	2.52	0.20
	Intermuscular fat	2.67[a]	1.69[b]	0.24
	Total fat	5.87[a]	4.21[b]	0.32
	Bone	30.87	31.69	0.46
	Muscle	62.09	61.58	0.37
	Losses	0.38	1.42	0.23
Neck	Subcutaneous fat	6.89	6.43	0.51
	Intermuscular fat	4.22	3.15	0.44
	Total fat	11.11	9.58	0.55
	Bone	28.53	29.30	0.66
	Muscle	55.18	50.67	1.08
	Losses	4.09	8.57	1.12
Long leg	Subcutaneous fat	4.55	3.59	0.31
	Intermuscular fat	3.64a	2.46b	0.23
	Total fat	8.19a	6.05b	0.41
	Bone	30.16	29.94	0.46
	Muscle	60.26	61.93	0.40
	Losses	0.49	1.03	0.13
Flanks	Subcutaneous fat	6.49	5.55	0.43
	Intermuscular fat	6.95a	4.70b	0.57
	Total fat	13.44a	10.25b	0.71
	Bone	29.68	31.85	0.99
	Muscle	54.19	54.34	1.01
	Losses	0.47	0.43	0.12
Ribs	Subcutaneous fat	5.44a	3.88b	0.31
	Intermuscular fat	3.96a	2.66b	0.32
	Total fat	9.40a	6.54b	0.49
	Bone	33.80	34.93	0.75
	Muscle	53.18	52.97	0.63
	Losses	1.61	3.06	0.30

[1], Proportions in carcass weight, [2], Proportions in joint weight.
Values with different letters on the same row are statistically different.

Table 14.7. Effects of diet on M. Longissimus dorsi attributes in kids fed milk or milk replacers (Argüello *et al.*, 2005)

	Goat milk	Milk replacers
pH [1]	6.08±0.24	6.30±0.31
pH [2]	5.59±0.18	5.73±0.01
L [1]	50.07±3.92	49.53±3.00
L [2]	56.57±4.82	56.93±3.96
Chroma[1]	9.08±1.72	10.45±2.43
Chroma [2]	13.76±3.99[a]	16.11±5.69[b]
Hue [1]	26.79±12.25	29.75±8.94
Hue [2]	43.99±7.67	42.08±6.09
SF (N)	50.07±14.93	55.71±13.41
WHC (g)	0.66±0.11a	0.46±0.10b
Moisture (%)	78.21±0.38	78.40±1.20
Protein (%)	18.67±0.72	19.05±1.74
Fat (%)	1.26±0.41	0.96±0.44
Ash (%)	1.15±0.09	1.12±0.05
Collagen (%)	0.60±0.13	0.46±0.16
Coll. Sol. (%)	70.49±8.47	85.62±15.84
% Type I	24.00±11.43	32.91±22.67
% Type IIA	46.00±10.70	35.50±15.68
% Type IIB	30.00±4.00	31.85±19.30
Type I (μ^2)	484.27±151.88	389.10±123.79
Type IIA (μ^2)	541.23±224.02	354.16±164.43
Type IIB (μ^2)	472.49±166.04	367.02±86.79

[1]. At slaughter; [2]. After chilling; L: lightness; SF: Shear force; WHC: Water holding capacity; Coll. Sol.: Collagen solubility. Data shown in mean±standard deviation.
Values with different letters on the same row are statistically different.

Table 14.8. Effects of diet on M. Triceps brachii attributes in kids fed milk or milk replacers (Argüello *et al.*, 2005)

	Goat milk	Milk replacers
pH [1]	6.34±0.21	6.53±0.27
pH [2]	5.82±0.10	5.80±0.14
L [1]	53.08±4.61	53.60±3.95
L [2]	56.33±3.08	55.47±4.98
Chroma[1]	12.50±3.36	11.03±1.41
Chroma [2]	13.99±2.46[a]	15.26±1.76[b]
Hue [1]	31.34±8.93	31.87±6.74
Hue [2]	39.82±7.83	38.29±10.36
SF (N)	83.18±8.64a	88.40±6.85b
WHC (g)	0.41±0.08a	0.33±0.07b
Moisture (%)	78.38±1.41	78.55±0.40
Protein (%)	17.54±2.07	18.53±0.69
Fat (%)	0.84±0.22	1.08±0.51
Ash (%)	1.08±0.07	1.16±0.07
Collagen (%)	0.49±0.06	0.40±0.06
Coll. Sol. (%)	83.04±3.04	83.09±12.14
% Type I	29.49±8.63	17.53±12.72
% Type IIA	40.13±9.90	36.18±19.26
% Type IIB	30.37±6.51	46.28±11.55
Type I (μ^2)	596.22±126.13	570.73±134.55
Type IIA (μ^2)	707.24±238.84	636.02±123.01
Type IIB (μ^2)	678.77±254.48	640.60±142.63

[1]. At slaughter. [2]. After chilling. L: lightness. SF: Shear force. WHC: Water holding capacity. Coll. Sol: Collagen solubility. Data shown in mean±standard deviation.
Values with different letters on the same row are statistically different.

Table 14.9. Effects of diet on M. Semimembranosus attributes in kids fed milk or milk replacers (Argüello *et al.*, 2005)

	Goat milk	Milk replacers
pH [1]	6.09±0.27	6.39±0.22
pH [2]	5.58±0.04	5.64±0.07
L [1]	47.13±17.32	54.43±3.11
L [2]	53.61±5.47	54.49±2.11
Chroma[1]	9.73±2.34	11.87±2.61
Chroma [2]	12.43±2.24[a]	14.46±3.64[b]
Hue [1]	34.57±13.71	32.28±7.01
Hue [2]	44.93±12.01	41.28±6.62
SF (N)	32.64±11.87[a]	43.67±6.24[b]
WHC (g)	0.72±0.16[a]	0.60±0.15[b]
Moisture (%)	78.46±0.50	78.51±0.88
Protein (%)	18.20±0.99	18.10±1.65
Fat (%)	0.91±0.34	1.10±0.51
Ash (%)	1.18±0.06	1.18±0.09
Collagen (%)	0.46±0.05	0.42±0.09
Coll. Sol. (%)	81.52±10.48	74.69±8.77
% Type I	9.75±5.68	31.40±25.65
% Type IIA	84.25±4.27	13.83±9.24
% Type IIB	6.00±1.82	54.77±34.61
Type I (μ^2)	508.45±93.47	528.04±106.56
Type IIA (μ^2)	564.45±198.00	602.65±138.86
Type IIB (μ^2)	565.55±146.38	586.34±129.95

[1]. At slaughter. [2]. After chilling. L: lightness. SF: Shear force. WHC: Water holding capacity. Coll. Sol: Collagen solubility. Data shown in mean±standard deviation.
Values with different letters on the same row are statistically different.