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The effect of maternal or artificial milk, age and sex on three muscles fatty acid profile of Damascus breed goat kids

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ABSTRACT

Meat quality is related to a variety of muscle types consisting of different muscle fibers which are a reflection of its energy requirements and lipid content. Due to that, factors such as source of suckled milk, age and sex which affect the fatty acid (FA) profile and associated with meat quality should be determined in different muscles, since humans consume different parts of the carcass. A total of 40 goat kids of Damascus breed were used to determine the effect of rearing system, age and sex on the FA profile of *Semimembranosus proprius* (SP), *Longissimus dorsii* (LD) and *Triceps brachii* (TB). The goat kids were assigned into two groups balanced for body weight and sex. The first group (n=20), (10 male and 10 female goat kids) underwent natural rearing and received only maternal milk until weaning. The second group (n=20) (10 male and 10 female goat kids), was subject to artificial suckling with a commercial milk replacer. At weaning (49 days of age), 10 animals from each group were weighed and slaughtered. The remaining goat kids of both groups, after weaning were fed daily 100 g barley hay per animal and a commercial concentrate diet *ad libitum* up to 98 days of age, where they were also weighted and slaughtered. The results showed that the body weight and the growth rate were significantly higher in males than females goat kids when fed with maternal milk. Moreover, the growth rate was significantly higher in the naturally compared with the artificially goat kids. The muscles FA composition, especially the branched chain FA, saturated FA and n-3 FA, reflects that of the milk source (maternal or artificial). Significant differences were found among the three muscles (SP, LD and TB) of goat kids for several individual FAs. The concentrations of C18:0 and *trans* C18:1 FA increased significantly whereas n-3 FAs decrease in the fat of goat kids slaughtered at 98 compared 49 days of age, due to the shift from milk to a fodder diet. Sex did not affect the FA profile of goat kids. In conclusion, naturally reared goat kids is better slaughtered at younger age before a shift from milk to a fodder diet whereas a fodder diet compared with a milk replacer can improve muscle FA profile of goat kids.

1. Introduction

Consumer interest in animal products is influenced by the perception of “food healthiness” , which in the case of meat is largely related to intramuscular fat content and fatty acid (FA) profile (McAfeea et al., 2010). Goat kid meat gained acceptance because of its low intramuscular fat, particularly appreciated if obtained from suckling animals slaughtered up to 70 days of age (Santos-Silva et al., 2002). In most cases, these young animals are almost exclusively fed on maternal milk and some small amounts of hay plus concentrates, progressively. However, there is an increasing trend to use artificial suckling with milk replacers, in order to increase the farm income by selling all the milk on the market (Delgado-Pertíñez et al., 2009). Despite the fact that artificial suckling may increase farm income, limited information exists regarding the impact of milk replacers on goat kid meat FA profile (Bañón et al., 2006). Further to that, contradictory results exist concerning the effect of milk replacers on the growth rate of goat kids. More specifically higher growth rate in naturally suckled goat kids compared with artificially fed kids was found by Argüello et al. (2004) while no difference in the growth rate was found between goat kids fed either with maternal or artificial milk (Delgado-Pertíñez et al., 2009). However, it should be pointed that rearing system does not have a strong influence on post-weaning animal performance (fattening) (Norouzian and Valizadeh,

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2011) since it does not affect the sequence and time in which the functional groups of microorganisms are established in the goats kid rumens (Paez-Lama et al., 2015).

Despite the fact that the FA profile of meat should be obtained from a mixture of major muscles, since humans consume different parts of the carcass, the factors which affect goat kid meat FA composition such as slaughter weight (Peña et al., 2009; Cividini et al., 2014), breed (Peña et al., 2009; 2011; Ripoll et al., 2012), sex (Bonvillani et al., 2010; Cividini et al., 2014) and diet (Najafi et al., 2012; Ozcan et al., 2014) have been studied in only one muscle, being *Longissimus dorsii* (LD) the most common reference muscle.

Moreover, muscles are characteristically quite diverse, consisting of different types of muscles fibers which have different patterns of oxidative and/or glycolytic metabolism (Lee et al., 2010). Meat quality can be influenced by muscle type (slow-oxidative or type I, fast oxido-glycolytic or type IIA and fast glycolitic IIX or IIB) (Schreurs et al., 2008; Choi and Kim, 2009; Lee et al., 2010). Besides, muscle type is a reflection of the energy requirements of the muscle (Hocquette et al., 1998; Oddy et al., 2001) since changes in FA composition within muscle are associated with changes in the proportions of muscle fiber types (Jurie et al., 2005; Alfaia et al., 2007). Additionally, type I fibers contain a higher amount of lipid and lower amounts of glycogen and glucose than type IIB fibers (Peter et al., 1972; Hintz et al., 1984). It is well known that both *Longissimus dorsii* (LD) and *Semimembranosus proprius* (SM) are glycolytic muscles while *Tricepts brachii* (TB) is oxidative (Dinh et al., 2011) and represent different anatomical regions and divergent functionalities. Thus, taking into account all the above, the aim of this work was to study the effect of goat milk or milk replacer diet, age and sex on the FA profile of LD, SM and TB of goat kids as well as on their average growth rate.

2. Materials and methods

2.1. Experimental design

The study was carried out at the Athalassa Experimental Farm of the Agricultural Research Institute of Cyprus. A total of 40 goat kids from Damascus breed were selected from goats which delivered twins or triplets at a kidding interval of 2–3 days in February. The goats were fed barley hay, lucerne hay and a concentrate diet plus pasture *ad libitum*. The concentrate contained (g/kg fresh weight): barley grain, 400; corn grain, 200; sunflower cake (35% CP), 100; soybean meal (48% CP), 56; wheat middling, 71; corn gluten, 58; rapeseed, 40; sugar beet pulp, 40; minerals and vitamins premix, 35. The kids, of 1–2 days old, were assigned into two homogenous subgroups according to their body weight (BW) and sex. The first group (n=20), comprised of 10 male (BW=4.2 ± 0.4 kg) and 10 female (BW=4.0 ± 0.3 kg) kids, underwent natural rearing and received only maternal milk ad libitum until weaning. The second group (n=20), comprised also of 10 male (BW=4.0 ± 0.2 kg) and 10 female kids (BW=3.9 ± 0.4 kg), was subject to artificial suckling with a commercial milk replacer. The artificial milk replacer consisted of (g/kg dry matter): fat enriched in milk whey, 445; milk whey, 246; low lactose milk whey, 136; soy protein, 109; hydrolyzed wheat gluten, 36; and dextrose, 28 and was offered to the group of goats kids ad libitum. All kids were weaned at the average age of 49 ± 0.9 days, where 10 animals from both groups were weighed and slaughtered. The remaining kids of both groups, after weaning were fed daily 100 g (fresh weight) barley hay per animal, which was consumed entirely, and with a commercial concentrate diet *ad libitum*, which contained (g/kg): barley grain, 533; sunflower cake (35% CP), 100; soybean meal (48% CP), 73; sugar beet pulp, 60; wheat middling, 60; corn grain, 50; rapeseed, 40; corn gluten, 40; carob flour, 10; minerals and vitamins premix, 34 up to 98 ± 0.9 days of age. Then, they were weighed and slaughtered. The body weight of the kids was recorded at weaning and at weekly intervals throughout the experimental period to calculate the average growth rate.

2.2. Muscle sampling

The kids were slaughtered in a licensed private abattoir according to the EU Council Directive 86/609/EEC that establishes guidelines regarding the protection of animal used for experimental and other scientific purposes. More specifically, immediately after goats kids arrived at the abattoir, they were kept in covered yards, were deprived of food (for 12 h) and had free access to water. After weighing the goats kids were electrically stunned and slaughtered according to standard commercial procedures (EC, 1099/2009). Carcasses were immediately transferred to a cooler room and after a 24 h chilling at 4 °C, samples of *Longissimus dorsii* (LD), *Tricepts brachii* (TB) and *Semimembranosus proprius* (SM) muscles were collected from the right side of each carcass. The sample of LD was excised from the level of 13th thoracic rib, while the entire TB and SM muscles were collected. Samples were stored at −80 °C until FA analysis.

2.3. Feed sampling

Six individual samples from lucerne hay, barley hay and concentrates were taken at the beginning of the experiment for FA profile determination (Table 1).

2.4. Milk sampling

Individual milk samples were collected from 15 goats twice at 20 and 45 days after kidding. On the same days, 3 individual milk samples were taken from the artificial milk. All milk samples were analyzed for FA (Table 2).

2.5. Fatty acid analysis

Muscle samples were partially thawed at 4 °C and trimmed to remove any external adipose and connective tissue. Total meat FA were extracted and methylated directly, according to the method of O' Fallon et al. (2007). More specifically, duplicate 1 g of muscle samples were hydrolyzed for 1.5 h at 55 °C in 1 N potassium hydroxide in methanol, containing a known amount (approx. 0.5 mg) of tridecanoic acid (13:0) methyl ester as internal standard. The potassium hydroxide was then neutralized and the free fatty acids were methylated by sulphuric acid catalysis (24 N H_2SO_4) for 1.5 h at 55 °C. Hexane (3 ml) was added to the reaction tube, which was vortex-mixed and centrifuged. The supernatant hexane layer containing the fatty acid methyl esters was transferred into gas chromatography vials and kept at −20 °C until analyzed. Milk and milk replacer FA analysis was carried out according to the method

Table 1
The main fatty acids (% of total fatty acids) of concentrates, lucerne and barley hay.

Fatty acids	Concentrates		Roughage	
	Goats	Goat kids	Lucerne hay	Barley hay
C14:0	0.24	0.16	0.81	3.99
C16:0	15.92	17.10	24.38	30.63
C18:0	2.25	2.38	4.22	3.42
cis-9 C18:1	19.22	16.62	14.24	4.38
C18:2n-6c	56.55	56.92	16.32	39.72
C18:2n-6t	2.08	3.06	4.00	6.25
C18:3n-3	3.39	3.35	34.52	9.97
C20:0	0.35	0.27	1.52	1.64