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Allometric Growth of Non-Carcass Components and Hind Limb Tissue Composition in Saanen Goat Kids Reared Under Natural and Artificial Systems

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Abstract

The aim was to investigate the growth of certain non-carcass components and hind limb tissues using allometric coefficients in Saanen goat kids reared under natural and artificial systems and slaughtered at 80 days or 120 days of age. 42 Saanen kids were used in the study [(24 artificial reared kids (SA-80: 12 kids, SA-120: 12 kids), 18 natural reared kids (SA-80: 9 kids, SA-120: 9 kids)] for determination of indicated parameters. The effects of rearing system were not significant in weights of non-carcass components and hind limb tissue compositions, which indicate that, even though they were fed with milk replacers, artificial reared kids can have similar growth performance when they are slaughtered at similar age with natural raised kids. However, slaughter age had significant effect on many non-carcass components, since the weight of the organs increases in parallel with animal's live weight. It is seen that allometric growth of non-carcass parameters, except skin and testis in both rearing groups and stomach and intestines in natural rearing, was slower (b<1) than EBW of kids slaughtered at 120th days of age. This result shows that when the Saanen kids will be slaughtered at later ages, the increase of live weight will be mainly due to the increased saleable carcass components. Additionally, tissue compositions showed that muscle growth continued rapidly (b=1.494 for natural and b= 1.251 for artificial reared) in both groups on the 120th day of age. This situation reveals that prolonging the fattening period with Saanen kids can increase meat production for both rearing systems. On the other hand, it is observed that the amount of both subcutaneous and intermuscular fat increased more rapidly at the 120th day of age in both groups. Therefore, the optimal slaughter age at 120th days should be determined by taking into account the possible increasing amount of fat.

Keywords: Allometric coefficients; body development; Saanen breed; slaughter age; visceral organs

Introduction

Goat breeding in Turkey is mostly carried out by small family-type enterprises with poor housing and feeding conditions in villages and rural areas. Goat farming, which provides 1.93% of meat production and 2.51% of milk production in Turkey has great importance in the economy and nutrition of the villagers, especially in rural areas.[1] The vast majority of the goat population in Turkey consists of Hair goats that are well adapted to inadequate housing and feeding conditions under an extensive production system.[2] Kid sales constitute the main income item in goat production, which is carried out in an extensive system with indigenous breeds. In addition, although it varies according to the conditions of the farm, goats are usually milked for a short time after the kids are weaned.

In recent years, the demand for goat milk and products obtained from goat milk (cheese, ice cream, yoghurt) has increased. In order to meet this demand, it is seen that the number of enterprises targeting milk production with Saanen goats in the intensive system has increased rapidly. In this production system, to obtain more marketed goat milk, goat kids are mostly weaned at early ages and

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reared in artificial rearing systems.[3] Although low weight carcasses are obtained, male goat kids are usually slaughtered at the end of the rearing period for meat production and constitute a secondary income item for the enterprise. Therefore, in this production model, the meat production potential of male kids cannot be utilized sufficiently. [4]

In slaughtered farm animals, the percentages of non-carcass components (such as head, skin, feet, gastro-intestinal tract) and tissue composition in the carcass (proportions of meat, fat, bone) are the main criteria that determine the dressing percentage and the carcass quality, respectively.[5] On the other hand, the development of various non-carcass components and body tissues is not simultaneous. In order for the new-born to survive, bones and vital organs are well developed at birth and therefore develop slowly after birth. In contrast, muscle and fat tissues, which are the main components of the carcass, mature later.[5,6] For differential growth of this kind, the term "allometry" has been generally recognised, which states that the rate of relative growth of an organ is a constant fraction of the relative growth of the total organism.[7,8] Besides, the allometric growth rates of each organ and tissue can vary according to management and feeding conditions.[9] Therefore, knowing the allometric growth of organs and tissues can contribute to the establishment of feeding programs and the determination of optimum slaughter weight and/or age for farmers who want to obtain quality carcasses at the end of an efficient fattening program. Allometric growth of various organs and body tissues can be measured with nonlinear models[9], and the equation developed by Huxley[7] is one of the most common models used for this purpose.

The aim of the current study was to assess the development of non-visceral body components, internal organs and hind limb tissue composition based on allometric coefficients in Saanen goat kids reared under natural and artificial systems. Besides, in order to determine the development of the investigated carcass and non-carcass components depending on the slaughter age, goat kids slaughtered at two different ages (80 and 120 days) in both rearing systems were examined.

Materials and Methods

1. Animals, Experimental Design and Handling Procedures

The Ethics Committee of Istanbul University approved the experimental protocol of the current study (Approval number: 2014/17).

The study was carried out at private dairy goat farm (Evla Goat Farm, Catalca, Istanbul, Turkey), which the kids were raised under intensive farming conditions. The forty-two male Saanen kids included in the study were selected considering to their birth date, birth type and live weights. Saanen kids were raised under two different rearing types [natural rearing (NR) and artificial rearing (AR)] and were slaughtered at two different age (80 d and 120 d). Four experimental groups in the present study were:

1. AR-80 (n=12): These kids were separated from their dams immediately after kidding and received colostrum by a nursing bottle for first two days. After 3 days of age, kids were fed a mix of dam's milk and commercial milk replacer by a milk feeder bucket until 10 days of age. After that they were fed 100% milk replacer (95.5% dry matter, 23.13% crude protein, 15.46 MJ ME/kg DM) until slaughter age which was 83 days of age. Concentrate feed and dry grass were also supplied to the animals after 21 days of age.

2. AR-120 (n=12): These kids were fed with the same principles like AR-80 group until 83 days of age. Feeding of milk replacer to the kids was stopped at an average of age 83 days. After that kids were fed only grower concentrate feed (87.5% dry matter, 14.31% crude protein, 11.09 MJ ME/kg DM and dry grass (88.5% dry matter, 7.13% crude protein, 8.81 MJ ME/kg DM) constantly until slaughter age which was 120 days of age.

Besides the milk replacer, AR kids received starter concentrate feed (86.9% dry matter, 17.69% crude protein, 11.24 MJ ME/kg DM) and dry grass (88.5% dry matter, 7.13% crude protein, 8.81 MJ ME/kg DM) after 21 days of age until 83 days of age. AR kids were placed into pens with 0.70 m2 area per animal and each kid could easily reach milk feeder buckets.

3. NR-80 (n=9): These kids were kept with their dams and suckled their dams until 45 days of age. Each goat used 2.3 m2 indoor and 2.2 m2 backyard area with their kids. Starter concentrate feed and dry grass were supplied to the kids from second week after kidding until 83 days of age which was slaughter age. Kids weaned at 45 days of age in NR groups and after that they were placed into pens with 0.70 m2 area per animal.

4. NR-120 (n=9): These kids were fed with the same principles like NR-80 group until 83 days of age. After that grower concentrate feed and dry grass were supplied to the kids constantly until 120 days of age.

When the kids reached slaughter age (83 d or 120 d), they were transported to abattoir.

2. Slaughter and Carcass Characteristics

Live weight of each kid was recorded before slaughter.

After removing and weighing non-carcass components (head, skin, feet, lungs and trachea, liver, heart, spleen, pancreas, gastrointestinal tract and testicles) hot carcass weights were also recorded. The empty body weight (EBW) was calculated by subtracting the contents of the gastro-intestinal tract from pre-slaughter live weight. The EBW of all groups were determined as NR-80: 8,16±0,69; NR-120: 10,41±0,69; AR-80: 8,36±0,60; AR-120: 9,66±0,60, respectively. Carcasses were kept at 4°C for 24 h before carcass splitting. Right halves of each cold carcass were split as shoulder, flank, neck, ribs, and hind limb according to the methodology of Colomer-Rocher et al.[10]. Each right hind limb was vacuum packed after weighing and kept at -18°C until determination of tissue composition. Many previous studies reported that hind limb tissue composition is the most suitable carcass joint for prediction of carcass tissue distribution.[11-14] Therefore, hind limb joint was dissected into muscle, bone, subcutaneous fat, intermuscular fat and other tissues by the dissection method described by Fisher and De Boer[15].

3. Statistical Analyses

Firstly, data for weights of non-carcass components and hind limb tissues were analysed with GLM that includes fixed effects of rearing system, slaughter age and rearing system × slaughter age interaction. Then, allometric growth of non-carcass components and hind limb tissues were estimated by the nonlinear allometric equation specified by Huxley[7]:

$Y = aX^b$,

where, Y: weights of non-carcass components, visceral organs and hind limb tissues; a: intercept value of regression model; X= empty body weight for non-carcass components and visceral organs / hind limb weight for hind limb tissues; b: allometric coefficient.

Allometric coefficient (b) indicates the relative growth rate of investigated non-carcass components and hind limb tissues relative to the empty body weight or hind limb weight, respectively.5 b = 1 indicates the isogonic growth rate of the investigated component/tissue with the empty body or hind limb. b>1 indicates a faster growth rate of investigated non-carcass components and hind limb tissues to empty body or hind limb, while b<1 indicates a lower growth rate of the investigated dependent variable.[5,16]

Both GLM and nonlinear regression analyses were performed using SPSS 21.0 Programme (SPSS Inc., IBM, NY, USA).

Results

Weights of non-carcass components and visceral organs of Saanen kids from different rearing and slaughter age groups were presented in Table 1. The kids from SA-120 group had higher values than the SA-80 group for almost all investigated parameters, except liver, spleen and empty stomach weights. However, the effects of rearing type and slaughter age × rearing system interaction were not significant for the investigated non-carcass components.

Table 1. Weights of non-carcass components and visceral organs according to rearing system × slaughter age sub-groups

Component	Natural Rearing		Artificial Rearing		Significance (P-value)		
	SA-80	SA-120	SA-80	SA-120	SA	RT	SA × RT
Head, kg	0.74±0.054	0.91±0.054	0.76±0.047	0.96±0.047	**0.001**	0.500	0.790
Feet, kg	0.37±0.019	0.44±0.019	0.37±0.016	0.42±0.016	**0.003**	0.626	0.617
Skin, kg	0.64±0.069	0.95±0.069	0.67±0.059	0.82±0.059	**0.001**	0.417	0.195
Visceral organs, kg	0.60±0.052	0.74±0.052	0.57±0.045	0.68±0.045	**0.016**	0.395	0.851
Lung and trachea, kg	0.16±0.025	0.20±0.025	0.16±0.022	0.22±0.022	**0.044**	0.745	0.849
Heart, kg	0.05±0.004	0.06±0.004	0.05±0.003	0.06±0.003	**0.004**	0.874	0.305
Liver, kg	0.26±0.025	0.31±0.025	0.23±0.022	0.28±0.022	0.053	0.188	0.920
Spleen, g	0.02±0.002	0.02±0.002	0.02±0.002	0.02±0.002	0.666	0.969	0.292
Testis, kg	0.02±0.008	0.04±0.008	0.02±0.007	0.04±0.007	**0.019**	0.528	0.982
Kidney, g	0.04±0.003	0.06±0.003	0.04±0.003	0.05±0.003	**0.004**	0.714	0.498
Empty Stomach, kg	0.43±0.041	0.52±0.041	0.42±0.035	0.52±0.035	**0.020**	0.977	0.845
Empty intestine, kg	0.85±0.071	0.87±0.071	0.79±0.062	0.87±0.062	0.486	0.653	0.626

Weights of hind limb tissues according to rearing system × slaughter weight sub-groups were presented in Table 2. Only significant difference amongst the slaughter age groups was the bone weight and it was higher in SA-120 groups than SA-80 ones. Similar to non-carcass components, the effects of rearing type and slaughter age × rearing type interaction were not significant.

Table 2. Weights of hind limb tissues according to rearing system × slaughter age sub-groups

Hind limb tissue	Natural Rearing		Artificial Rearing		Significance (P-value)		
	SA-80	SA-120	SA-80	SA-120	SA	RT	SA × RT
Muscle, g	235.39±31.526	308.16±31.526	271.21±27.302	306.87±27.302	0.074	0.562	0.533
Bone, g	178.07±9.457	232.30±9.457	178.21±8.190	221.36±8.190	**<0.001**	0.545	0.535
Subcutaneous fat, g	3.40±3.317	7.14±3.317	3.40±2.87	9.09±2.872	0.137	0.756	0.755
Intermuscular fat, g	31.33±5.461	39.03±5.461	26.26±4.729	34.50±4.729	0.127	0.354	0.958
Total fat, g	34.73±7.705	46.17±7.705	29.66±6.673	43.59±6.673	0.086	0.598	0.863

Intercepts (a) and allometric coefficients (b) of nonlinear allometric growth equation for weights of non-carcass components and visceral organs according to slaughter age groups in natural rearing system were presented in Table 3. The differences between SA-80 and SA-120 groups for both intercepts and allometric coefficients was found not significant for all investigated parameters for natural rearing system. Allometric coefficients of head, feet, skin, lung and trachea, heart and spleen weights of SA-80 groups were found lower than 1 and especially spleen had the slowest growing rate amongst the investigated parameters. On the other hand, visceral organs, liver, testis, kidneys, stomach and intestines showed faster growth rates for SA-80 kids.

Head, feet, visceral organs, lung and trachea, heart, liver, spleen and kidney exhibited a slow growing rate for SA-120 group. However, skin showed an increased growth rate when it is compared to the SA-80 group.

Table 3. Intercept and allometric coefficient values of nonlinear allometric growth equation for weights of non-carcass components and visceral organs according to slaughter age groups in natural rearing system.

Component	a values (Intercept)			b values (Allometric coefficients)			Pooled RSE	R^2
	Overall	Slaughter age		Overall	Slaughter age			
		SA-80	SA-120		SA-80	SA-120		
Head	0.169	0.172	0.229	0.712	0.696	0.589	0.038	0.886
Feet	0.138	0.132	0.217	0.483	0.492	0.298	0.013	0.598
Skin	0.036	0.386	0.048	1.378	0.238	1.272	0.048	0.710
Visceral organs	0.111	0.068	0.131	0.806	1.043	0.738	0.037	0.709
Lung and trachea	0.056	0.034	0.123	0.527	0.746	0.202	0.018	0.330
Heart	0.006	0.009	0.009	0.957	0.775	0.831	0.003	0.851
Liver	0.045	0.024	0.036	0.824	1.131	0.915	0.018	0.510
Spleen	0.011	0.041	0.002	0.284	-0.307	0.971	0.002	0.030
Testis	0.000	0.000	0.000	2.346	2.458	2.182	0.005	0.398
Kidney	0.006	0.005	0.008	0.923	1.035	0.812	0.002	0.720
Empty Stomach	0.043	0.009	0.024	1.071	1.853	1.308	0.029	0.673
Empty intestine	0.167	0.019	0.052	0.738	1.808	1.201	0.051	0.420

When the allometric analysis were investigated for weights of hind limb tissues according to slaughter age groups in natural rearing system, the difference amongst the slaughter age groups was also found not significant, similar to non-carcass components (Table 4). Bone, subcutaneous fat and total fat tissues of SA-80 kids had slower growth rates than muscle and intermuscular fat. Subcutaneous fat was the slowest growing tissue when it was compared to others for SA-80 kids. While bone was the slowest growing tissue for SA-120 kids, growth rate of total fat visibly increased when it was compared to SA-80 kids' total fat values. This result indicates that total fat tissue in goat carcasses tends to increase with the age.

Table 4. Intercept and allometric coefficient values of nonlinear allometric growth equation for weights of hind limb tissues according to slaughter age groups in natural rearing system.

Hind limb tissues	a values (Intercept)			b values (Allometric coefficients)			Pooled RSE	R^2
	Overall	Slaughter age		Overall	Slaughter age			
		SA-80	SA-120		SA-80	SA-120		
Muscle	0.528	0.617	0.602	1.126	1.282	1.494	0.022	0.825
Bone	0.303	0.258	0.274	0.648	0.487	0.353	0.007	0.591
Subcutaneous fat	0.020	0.000	0.019	2.352	-2.443	2.178	0.005	0.246
Intermuscular fat	0.070	0.073	0.096	1.159	1.126	2.019	0.004	0.287
Total fat	0.086	0.069	0.115	1.293	0.903	2.051	0.005	0.339

The values of nonlinear allometric growth equation for weights of non-carcass components and visceral organs according to slaughter age groups in artificial rearing system were presented in Table 5. Similar to natural rearing, SA-80 kids had slow growing rate for head, feet, skin, lung and trachea, however different from natural rearing, allometric growth of stomach was slower than their counterpart. For the SA-120 kids, head, feet, visceral organs, lung and trachea, heart, spleen, kidney, stomach and intestine developed earlier and therefore had slower allometric growth, while skin, liver, and testis had faster growth rate and developed late.

Table 5. Intercept and allometric coefficient values of nonlinear allometric growth equation for weights of non-carcass components and visceral organs according to slaughter age groups in artificial rearing system.

Component	a values (Intercept)			b values (Allometric coefficients)			Pooled RSE	R^2
	Overall	Slaughter age		Overall	Slaughter age			
		SA-80	SA-120		SA-80	SA-120		
Head	0.152	0.216	0.188	0.790	0.595	0.722	0.033	0.675
Feet	0.096	0.124	0.099	0.648	0.516	0.640	0.011	0.857
Skin	0.068	0.085	0.073	1.086	0.971	1.062	0.042	0.960
Visceral organs	0.066	0.059	0.072	1.023	1.072	0.991	0.032	0.902
Lung and trachea	0.040	0.020	0.071	0.710	0.958	0.503	0.015	0.128
Heart	0.008	0.006	0.009	0.842	1.019	0.807	0.002	0.799
Liver	0.022	0.017	0.025	1.099	1.226	1.060	0.015	0.847
Spleen	0.002	0.001	0.003	0.971	1.312	0.925	0.001	0.692
Testis	0.000	0.001	0.000	2.108	1.404	1.972	0.005	0.907
Kidney	0.007	0.004^{e}	0.009^{d}	0.849	1.133	0.780	0.002	0.888
Empty Stomach	0.060	0.070	0.070	0.942	0.846	0.888	0.025	0.764
Empty intestine	0.107	0.084	0.100	0.933	1.057	0.953	0.044	0.878

d, e: The values with different letters are significantly different ($P < 0.05$).

When the allometric analysis were investigated for weights of hind limb tissues according to slaughter age groups in artificial rearing system, the difference between intercept values for muscle and both intercept and allometric coefficients of subcutaneous fat were found significant. Although, muscle, bone, intermuscular fat and total fat growth rate of artificial rearing kids from SA-80 and SA-120 were similar. On the other hand, while allometric growth of subcutaneous fat tissue was slow in SA-80 kids, the SA-120 kids had extremely fast growing subcutaneous fat tissue, which indicates that with the increased age, subcutaneous fat tissue of kids grows rapidly.

Table 6. Intercept and allometric coefficient values of nonlinear allometric growth equation for weights of hind limb tissues according to slaughter age groups in artificial rearing system.

Hind limb tissues	a values (Intercept)			b values (Allometric coefficients)			Pooled RSE	R^2
	Overall	Slaughter age		Overall	Slaughter age			
		SA-80	SA-120		SA-80	SA-120		
Muscle	0.575	0.678^{d}	0.565^{e}	1.185	1.357	1.251	0.019	0.960
Bone	0.278	0.230	0.284	0.547	0.370	0.480	0.006	0.672
Subcutaneous fat	0.033	0.006^{E}	0.033^{D}	4.057	0.777^{E}	4.113^{D}	0.006	0.955
Intermuscular fat	0.066	0.076	0.066	1.350	1.591	1.317	0.003	0.705
Total fat	0.103	0.081	0.104	1.890	1.498	1.906	0.005	0.897

d, e: The values with different letters are significantly different ($P < 0.05$).

D, E: The values with different letters are significantly different ($P < 0.01$).

Discussion

Non carcass components

Due to the increased intensification in small ruminant production, many breeders prefer to use milk replacement products for feeding lambs and kids, in order to benefit more from the milk produced by the mothers of these lambs and kids.[17] Since milk replacers are cheaper than natural goat milk and they help raising kids with substan-

tial average daily gain until slaughter age.[18] In some cases, rearing systems have significant effect on many slaughtering traits of goat kids[19,20], however, the differences amongst the rearing systems were not significant in investigated non-carcass components and hind limb tissue compositions. Similar to our findings, Argüello et al.[18] reported that feeding systems had no significant effect on offal components of kid carcasses. Panea et al.[21] also indicated that only significant difference between rearing groups were observed in visceral organs. This situation indicates that, even though they were fed with milk replacers, artificial reared goat kids can have similar non-carcass tissue growth performance with natural raised kids, when they slaughtered at similar age with natural raised kids.

On the other hand, slaughter age had significant effect on many non-carcass components, which is an expected result, since the weight of the organs increases in parallel with animal's live weight. Similar results were reported by Kaić et al.[22], about organ growth as the slaughter weight increases. Although, Rajkumar et al.[19], reported that most of the non-carcass component percentages, except testis, decreased with increasing weight of goat kids, similar to Karim et al.[23] and Peña et al.[24], however, all of them used the percentages of the indicated parameters, therefore, comparing the study findings with the reported results would be problematic.

Tissue composition

Only significant difference observed in weights of hind limb tissues was bone weight, which suggest that bone weight increases as the fattening period is prolonged, Argüello et al.[18] stated that natural reared kids had higher intermuscular and total fat than artificial reared ones, while there was no difference between groups in case of subcutaneous fat, muscle and bone proportions. In Panea et al.[21], while rearing system had no significant effect on bone percentages of dairy breed kids, the effect of slaughter weight was significant in meat breeds for all carcass tissue dissection traits. However, they reported that slaughter weight affects the goat breeds differently, while in some breeds the muscle proportion increases in parallel with slaughter weight, subcutaneous fat and intermuscular fat decreases, however in some cases, it is just the opposite. This situation indicates that optimal slaughter weight should be determined for each breed individually.

Allometric growth

Head, feet, lung and trachea, heart and spleen maturate even before 80th day of age in natural rearing systems, while visceral organs, liver, testis, kidney, stomach and intestines still continue to grow rapidly. When kids were slaughtered at 120th day of age, even though it completed its growth in SA-80 kids, skin continues to grow. On the other hand, testis, stomach and intestines had still rapid allometric growth at 120th day of age in natural fed goat kids, similar with the results with Peña et al.[24] and Morand-Fehr et al.[25] for gastro-intestinal tract and Garcia et al.[9] for testis.

Skin had an increasing growth rate in artificial rearing kids, similar to natural reared ones, since the b values of SA-120 kids was higher than SA-80 ones for both rearing types. This result may be related to the increase in hair amount along with the skin as age increases. Allometric coefficient values determined for liver weight indicate that growth of liver was faster than empty body weight in SA-80 group of natural rearing and SA-80 and SA-120 groups of artificial rearing systems. These results might be attributed to the fact that liver growth is dependent on the dietary energy level, which is higher in artificial milk products. Supporting the current results, a rapid growth rate of liver in artificially reared lambs had been reported by Santos[26] and Oliviera et al.[5]. Although not statistically significant, in this study, it was determined that the allometric growth coefficients for most of the non-carcass components decreased partially with increasing slaughter age. In many studies carried out to determine the effect of slaughter age on the proportions of non-carcass components, decreases in non-carcass components with increase in slaughter age were reported for various sheep and goat breeds. [24,25,27,28]

Vital organs (brain, eyes, head, feet, lungs, heart, etc.) and bone tissue are well developed at birth for a higher chance of survival5, which is the main reason for bone tissue to be the earliest maturing tissue component of the study, similar to Peña et al.[24], Sabbioni et al.[29] and De Sousa et al.[30]. On the other hand, muscle and fat tissues are late maturing tissues, which make the slaughter weight and dietary components quite important.[5] Muscle tissue continue to develop even after 120 days of age, which represents that higher slaughter weights can be used for both natural and artificial reared Saanen kids.

When animals reach maturity, protein deposition slows down while fat tissue deposition increases.[5] The "b" values for subcutaneous fat were "-2.443" for natural reared and "0.777" for artificial reared SA-80 kids. These results show that subcutaneous fat develops in the early stages, especially for natural rearing kids, and subcutaneous fat development is quite limited on the 80 days of age. On the other hand, the high "b" values in SA-120 in both groups indicate that the animals rapidly accumulate subcutaneous fat at

this age. In addition, it draws attention that the b values determined for artificial groups are higher than those for natural groups at both ages. This result can be explained by the high energy content of the artificial feed.

On the other hand, there was no difference amongst the groups in case of intermuscular fat for both rearing type and slaughter age. Intermuscular fat tended to be a late maturing tissue throughout the study, and even at the 120th day of age, the b value was higher than 1 for both natural and artificial reared kids. These results indicate that intermuscular adiposity was proportionally higher compared to the EBW increase at days 80 and 120 in both groups.

In SA-80 subgroup of natural reared goat kids' development of total fat tissue was similar with that of EBW, however, the growth rate of total fat was increased with the slaughter age. On the other hand, possibly because of the high energy intake from the beginning of the study, artificial reared kids had higher total fat growth rate throughout the study. Both Peña et al.[24] and De Sousa et al.[30] stated that higher slaughter weight represents fattier carcasses, which is quite similar to the current study findings.

Conclusion

Using milk replacers in kid rearing is becoming more and more common due to increasing intensive production. Since alternative rearing methods are becoming widespread, determining appropriate slaughter age/weight starts to be more crucial more than ever. However, rearing type had no significant effect on weights of investigated non-carcass parameters and hind limb tissue components. The study results indicated that artificial milk products can be preferred without having an adverse effect on kids' growth performance. On the other hand, slaughter age had a significant effect on many non-carcass traits and bone weight of the hind limb, which shows that higher slaughter age might result in increased weights of non-carcass components.

Investigating the allometric aspects of growth can be differentiated from comparing the weights/proportions of tissues. It is seen that allometric growth of non-carcass parameters, except skin and testis in both rearing groups and stomach and intestines in natural rearing, was slower than EBW of kids slaughtered at 120th days of age. This result shows that when the Saanen kids will be slaughtered at later ages, the increase of live weight will be mainly due to the increased saleable carcass components.

Additionally, hind limb tissue composition results showed that muscle growth continued rapidly in both groups on the 120th day of age. This situation reveals that prolonging the fattening period with Saanen kids can increase meat production for both rearing systems. On the other hand, it is observed that the amount of both subcutaneous and intermuscular fat increased more rapidly at the 120th day of age in both groups. Therefore, the optimal slaughter age after 120th days should be determined by taking into account the possible increasing amount of fat.

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