Effect of melatonin on growth performance in Saanen kids

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Abstract

This research was conducted to determine the growth performance of Saanen kids and to reveal the effects of maternal age, type of birth (single, twin or multiple), and sex on the properties of melatonin hormone to improve their growth performance. The research was carried out at Bursa Uludag University Research and Application Center of Veterinary Medicine. The animal material for the study consisted of 35 Saanen kids. Birth weight, 30th day, 60th day, 90th day, and 120th day live weights of Saanen kids were observed as 3.29 kg, 8.02 kg, 12.68 kg, 18.41 kg, and 21.26 kg, respectively. Birth weights were affected by maternal age and sex ($P < 0.001$). There was no significant difference between body weight and birth type. Comparisons of body weight between the 30th day melatonin-treated and 60th day melatonin-treated groups and the control group showed no significant differences. The findings underscore the potential of melatonin as a growth-promoting agent in goat farming, aligning with previous research that has demonstrated its positive effects on growth trajectories in various livestock species. Moreover, maternal age was found to positively influence birth weights, while no significant differences were observed based on the birth type. These findings contribute valuable insights into optimizing growth strategies in goat husbandry, highlighting the need for further comprehensive studies to fully elucidate the mechanisms and long-term effects of melatonin supplementation on growth and development in Saanen goats.

Goat farming, hormonal implants, maternal age

Goats have been an important resource for humans from the past to the present with the production of milk, meat, fleece and leather. Goat breeding creates an important source of income by employing the use of agricultural land, as well as meeting the need for animal protein, which has an important place in human nutrition. The benefits of goat breeding for humans are expected to increase in the coming years (Çelik and Oflaz 2017).

According to FAO data, while there were 349 million goats in the world in 1961, their numbers reached 1.1 billion in 2019, an increase of 188% (FAO 2019). Goat breeding in Türkiye is extremely important in both economic and social terms, providing the livelihood for many segments of population. Goat breeding importance declined in 1991–2010. While the number of goats was 10.7 million in 1991, it decreased to 6.3 million in 2010. However, the number has started to increase since 2010 due to the rising demand for goat milk and products (Republic of Türkiye General Directorate of Agricultural Enterprises 2019). The number of registered goats in 2019 was reported to be 11,205,429. The number of goats has increased by 7.57% in the last 5 years in Türkiye (Turkish Statistical Institute 2019).

The melatonin hormone is endogenously synthesized by the pineal gland in a daily circadian rhythm due to daylight (Zarazaga et al. 2009). Melatonin secreted from the pineal gland is thought to affect the growth and regulation of GH secretion (Falcón et al. 2003). It has been found that melatonin stimulates the growth hormone (GH) release faster than the gonadotropin-releasing hormone (GnRH). Additionally, melatonin has been found to increase GH levels in healthy individuals (Zeman et al. 1999). Many factors influence

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the growth of goat kids. Birth weight is one of them and the goat's vitality depends significantly on birth weight (Savaş 2007). Growth and development characteristics can be used as selection criteria at an early age. Various environmental and hormonal factors play a role in achieving the main goal of breeding, which is to obtain maximum benefit from each animal in the shortest time. Good growth performance can lead to effects such as earlier use of breeding age and reaching the slaughter weight sooner. This is very important for early breeding compared to others (Çelik and Oflaz 2017).

Melatonin has a wide range of physiological functions, including influencing bone remodelling, which is vital for maintaining bone health and density. This hormone directly affects osteoblast differentiation, increasing cellular proliferation and stimulating mineral formation, while also inhibiting osteoclastogenesis and reducing oxidative stress in bone cells. These properties of melatonin are crucial for bone metabolism and have implications for the development of new biomaterial bone substitutes and strategies for bone regeneration (de Almeida et al. 2022).

Recent research has further explored melatonin's multifaceted role beyond its well-known regulation of sleep-wake cycles. In livestock, melatonin influences seasonal reproduction, energy metabolism, and immune responses. Its potential in enhancing growth performance is associated with its ability to modulate photoperiodic signals, impacting metabolic processes and hormonal secretions related to growth. Melatonin's interaction with insulin-like growth factor 1 (IGF-1) and thyroid hormones could potentially optimize feed efficiency and growth rates in goat kids. Additionally, melatonin's antioxidant properties might reduce oxidative stress, thereby improving overall health and growth rates in young goats. Thus, investigating the exogenous application of melatonin could offer new insights into improving the productivity and economic efficiency of goat breeding practices (Contreras-Correa et al. 2023).

In goat breeding, it is economically important for goats to grow and gain live weight at an early age. In this study, we observed the effect of external melatonin hormone application on the growth performance of goat kids. In the case that melatonin application causes early growth in Saanen kids, it will be possible to use it in early breeding, and more productivity will be obtained from the unit animal.

Materials and Methods

The study was carried out in a semi-closed barn of the sheep and goat farming unit at Bursa Uludag University, Faculty of Veterinary Medicine, Research and Application Centre (40.23801, 28.88101), Türkiye. The average temperature in Bursa province was 13.6 °C between September and December and 10.12 °C between January and April. Saanen goats have been bred in the farm since 2005. Animals were bred every 4 years by artificial insemination using sperm sourced from Canada (Charella and Dandelion buck). At other times, the goats raised on the farm were used. It involved 35 Saanen kids born to 20 Saanen mothers on the research farm. The Saanen goats were tracked from the insemination season through the kidding period and beyond.

Goats nearing their due dates during the birthing season were placed in a separate section. Data on the mothers' earring number, maternal age, sex, birth type, and birth weight of each kid were recorded. After the kids were born, they were fed with colostrum.

During the feeding period of the goats, an average of 500 g of concentrate feed and 6 bales of hay and alfalfa box grass were given per goat *ad libitum*. In the last periods of pregnancy, the feeding programme of the goats was changed to 750 g concentrate feed and 7 bales of hay and alfalfa grass. Kids were fed on starter goat kid pellet, straw and alfalfa hay *ad libitum* until the weaning period. The feed composition analysis of the feeds given to the goats was calculated based on 100% dry matter and is presented in Table 1. Colostrum was provided to the kids within the first 3 h after birth. After colostrum, the kids were allowed to suck their mothers. The kids were kept with their mothers for two weeks. After the second week, mothers and kids were separated and sucking was done twice a day (09:00 h, 19:00 h). Clean water was available to kids at all times. On the 60th day, the kids are weaned.

Goat kids were divided into 3 groups (n = 35) based on the age of mother, sex, and birth type (single, twin or multiple). No application was made to the control group (n = 11). Group G30 included kids in which melatonin was applied on the 30th day day after birth (n = 12) using ear implants containing melatonin (18.0 mg) (Regulin, Ceva Animal Health, Libourne, France). Group G60 included kids in which melatonin was applied on the 60th day after birth (n = 12) using ear implants containing melatonin (Fig. 1). There were no differences in the nutritional and environmental conditions between the groups. The kids in each group were housed together in the barn.

Table 1. Composition analysis of the feed administered to the goats calculated based on 100% dry matter.

Feed	Dry matter	Starch	Ether extract	Ash	Crude protein	NDF	ADF	ADL	Pellet feed
Pellet feed	92.67	27.67	7.79	7.81	21.86	31.43	12.45	4.59	11.26
Straw	87.00	4.32	1.33	8.3	6.64	74.1	55.61	13.79	56.91
Alfalfa hay	87.22	3.42	1.77	10.61	13.55	53.07	49.4	13.26	51.92

NDF: Neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin

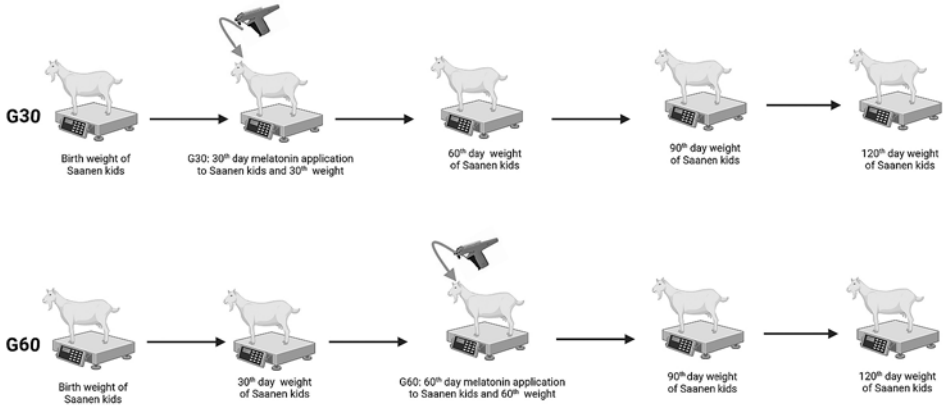

Fig. 1. Melatonin application in the two research groups of Saanen kids.

In the G30 group, melatonin was applied to the kids on the 30th day and their weights were recorded at birth, on the 30th, 60th, 90th and 120th days.
In the G60 group, melatonin was applied to the kids on the 60th day and their weights were recorded at birth, on the 30th, 60th, 90th and 120th days.

Goat kids were weighed at 30 day intervals to determine their growth performance in each group. The kids were starved overnight before weighing and care was taken to ensure that they were weighed under equal conditions. Scales sensitive to 50 grams were used for weighing. Absolute weights of the goat kids at 30, 60, 90, and 120 days of age were calculated by linear interpolation of weights obtained in consecutive measurements.

The growth characteristics and the effect of factors such as sex, birth type, and maternal age on the growth of the goat kids were analysed using the general linear model (GLM) procedure. The following model was used to calculate the growth characteristics:

$$Y_{ijk} = \mu + a_i + b_j + c_k + e_{ijk}$$

where Y_{ijk} represents the production of any animal, μ is the overall mean, a_i is the effect of maternal age, b_j is the effect of birth type, c_k is the effect of sex of goat kids, and e_{ijk} is random error. It was assumed that there were no significant interactions between the factors investigated, and the sum of the effects of the subgroups of factors was assumed to be zero. Data analysis considered significance at $P < 0.05$. The analyses were conducted using the statistical package program 'SPSS 23.0 for Windows'.

Results

Tables 2 and 3 present the averages and standard errors of Saanen kids' birth weights and weights on the 30th, 60th, 90th, and 120th days, categorized by birth type, maternal age and sex factors.

Average weights for Saanen male and female kids were as follows: birth weight 3.42 kg and 3.00 kg, 30th-day weight 8.39 kg and 7.23 kg, 60th-day weight 13.16 kg and 11.62, 90th-day weight 19.45 kg and 16.14 kg, 120th-day weight 22.11 kg and 19.40 kg, respectively.

The average weights of single, twins and triplets were found to be birth weight 3.60 kg, 3.26 kg, 3.24 kg, 30th-day weight 9.11 kg, 7.95 kg, 7.68 kg, 60th-day weight 13.65 kg, 12.64 kg,12.25 kg, 90th-day weight 19.63 kg, 18.59 kg, 17.11 kg, and 120th-day weight 24.13 kg, 21.24 kg, 19.67 kg respectively.

Table 2. Recorded weights of Saanen kids at birth and on the 30th day.

Factor		Birth weight			30th-day weight		
		n	$\bar{X}$	Sx	n	$\bar{X}$	Sx
Group	Control	11	3.30	0.16	11	8.27	0.64
	G30	12	3.25	0.14	12	7.85	0.25
	G60	12	3.33	0.13	12	7.97	0.44
Maternal age	Age 2	12	2.90[a]	0.11	12	8.05	0.29
	Age 3	11	3.43[b]	0.14	11	8.13	0.67
	Age 4 and older	12	3.55[bc]	0.09	12	7.90	0.38
Type of birth	Single	4	3.60	0.40	4	9.11	1.06
	Twin	24	3.26	0.08	24	7.95	0.29
	Triplet	7	3.24	0.18	7	7.68	0.57
Sex	Male	24	3.42[d]	0.09	24	8.39[f]	0.28
	Female	11	3.00[e]	0.14	11	7.23[g]	0.47
Total		35	3.29	0.08	35	8.02	0.26

[a, b, c] Means with different superscripts within the same column differ significantly at $P < 0.001$
[d, e, f, g] Means with different superscripts within the same column differ significantly at $P < 0.05$

Table 3. Recorded weights of Saanen kids on the 60th, 90th, and 120th day.

Factor		60th-day weight			90th-day weight			120th-day weight		
		n	$\bar{X}$	Sx	n	$\bar{X}$	Sx	n	$\bar{X}$	Sx
Group	Control	11	13.32	1.01	11	19.15	1.37	11	21.53	1.85
	G30	12	12.11	0.45	12	17.56	0.62	12	19.96	0.85
	G60	12	12.65	0.77	12	18.59	1.15	12	22.31	1.78
Maternal age	Age 2	12	13.26	0.58	12	18.76	0.83	12	22.90	1.61
	Age 3	11	12.69	0.92	11	18.76	1.20	11	21.37	1.23
	Age 4 and older	12	12.07	0.77	12	17.74	1.19	12	19.51	1.63
Type of birth	Single	4	13.65	1.73	4	19.63	2.25	4	24.13	1.65
	Twin	24	12.64	0.53	24	18.59	0.71	24	21.24	1.07
	Triplet	7	12.25	0.82	7	17.11	1.44	7	19.67	2.25
Sex	Male	24	13.16	0.53	24	19.45[a]	0.69	24	22.11[c]	0.77
	Female	11	11.62	0.67	11	16.14[b]	0.93	11	19.40[d]	2.21
Total		35	12.68	0.43	35	18.41	0.61	35	21.26	0.88

[a, b, c, d] Means with different superscripts within the same column differ significantly at $P < 0.001$

Average weights of Saanen kids were determined as follows: birth weight 3.29 kg, weight at 30 days 8.02 kg, weight at 60 days 12.68 kg, weight at 90 days 18.41 kg and weight at 120 days 21.26 kg, respectively (Tables 2 and 3).

Significant differences were found in Saanen kids between maternal age and birth weight, specifically between the maternal age of 2 and 3 years ($P < 0.001$), and maternal ages of 2 and 4 years and older ($P < 0.001$).

Significant differences were observed between male and female kids in terms of birth weight ($P < 0.05$), 30th-day weight ($P < 0.05$), 90th-day weight ($P < 0.001$), and 120th-day weight ($P < 0.001$). However, there were no significant differences between male and female kids in weight at the 60th-day ($P > 0.05$).

No significant differences were found between the birth type and birth weight, 30th-day weight, 60th-day weight, 90th-day weight, and 120th day weight ($P > 0.05$).

Similarly, no significant differences were observed between the experimental groups in terms of birth weight, 30th-day weight, 60th-day weight, 90th-day weight, and 120th-day weight and the groups ($P > 0.05$).

Discussion

The growth hormone supporting effect of external melatonin applications in small ruminants has been reported in different studies. The aim of this study was to determine the effect of external melatonin application on growth of Saanen kids in different periods (Molik et al. 2013). In this study, the average birth weight of Saanen kids was found to be 3.29 kg, which is higher than the 2.9 kg reported by Ceyhan and Karadag (2009) for Saanen kids. Values reported for Saanen × Hair F1 were 2.18 and 2.82 by Şimşek et al. (2007), and 2.95 by Şimşek and Bayraktar (2006). Tozlu (2006) reported a birth weight range of 2.86 kg to 3.59 kg, encompassing the value found in this study, which is also close to the 3.24 kg reported by Amoah (1996) and 3.22 kg reported by McManus (2008), as well as the 3.22 kg reported by Bolacalı and Küçük (2011). It matches the value of 3.3 kg reported by Uğur et al. (2004).

Male kids had a birth weight of 3.42 kg, while female kids had a birth weight of 3.00 kg, which is lower than the 3.53 kg in males and 3.31 kg in females reported by McManus (2008). Male kids consistently showed increased body weight compared to female kids across all growth periods, supported by declarations from Koşum et al. (2004), Şimşek et al. (2007), and Bolacalı and Küçük (2011).

The body weights on the 30th and 60th days were found to be 8.02 kg and 12.68 kg, respectively, considerably higher than the values reported for Saanen × Hair F1: 6.49 kg and 9.93 kg by Simsek et al. (2007), and 7.20 kg and 11.04 kg by Şimşek and Bayraktar (2006). Additionally, they were higher than the 6.59 kg and 9.88 kg reported by Bolacalı and Küçük (2011). However, the 30th-day weight of 8.02 kg was lower than the 8.86 kg reported by Tozlu (2006).

The weight on the 90th day, the first weighing after melatonin application on the 30th and 60th days, was 18.41 kg, significantly higher than the 17.50 kg reported by Uğur et al. (2004) and 13.18 kg reported by Gokdal et al. (2013). This increase can be attributed to the melatonin application. On the 120th day, the last weighing after melatonin application, the weight of 21.26 kg was close to the 21.50 kg reported by Uğur et al. (2004) and higher than the 15.35 kg reported by Bolacalı and Küçük (2011).

Considering the effect of maternal age on birth weight in Saanen kids, it was observed that the maternal age of 2 years or more had a positive effect on birth weight, consistent with findings reported by Duman and Demirören (2002), and Karadağ and Köycü (2011). Similarly, there was no significant difference in the effect of birth type on body weight increase in goats, as reported by Karadağ and Köycü (2011) and, Duman and Demirören (2002), contrary to the statement by Tozlu (2006).

The birth weight of kids born to mothers aged 4 years and above was found to be higher than that of kids born to younger mothers. This phenomenon can be attributed to maternal growth and uterine development, indicating significant environmental factors. The heritability of birth weight (r = 0.32) includes the effect of the 'maternal environment' as well as the direct genetic effect of the mother. As the heritability of individual birth weight is known to vary between h^2= 0.01 and 0.49 (Kaymakçı 1997; Burfening and Carpio 1993; Ünalan and Cebeci 2001; Hongping 2001), maternal effect on birth weight is highly significant. Similarly, the difference in birth weight between males and females is sex-dependent and consistent with existing literature. This difference persisted in weights at 30, 90, and 120 days. No statistically significant difference in performance was observed between the control and experimental groups throughout the study. The lower live weights observed

in the G30 group at 90 and 120 days compared to the control and G60 groups may indicate that melatonin administration was initiated prematurely. Conversely, the lack of significant differences suggests that melatonin application might be more effective if administered post-sexual maturity or closer to the breeding age, warranting further investigation.

In this study, the growth performance of Saanen goat kids was investigated with a focus on the application of melatonin hormone. Results showed that melatonin administration significantly enhanced growth rates, which is particularly evident in weights recorded on the 90th and 120th days post birth. The findings underscore the potential of melatonin as a growth-promoting agent in goat farming, aligning with previous research that has demonstrated its positive effects on growth trajectories in various livestock species. Moreover, maternal age was found to positively influence birth weights, while no significant differences were observed based on birth type. In our study, external melatonin application includes the period before weaning in both trial groups. Different studies are needed to investigate the effect of the application after the weaning period. These findings contribute valuable insights into optimizing growth strategies in goat husbandry, highlighting the need for further comprehensive studies to fully elucidate the mechanisms and long-term effects of melatonin supplementation on growth and development in Saanen goats.

In conclusion, this research conducted on Saanen goats is consistent with previous studies in terms of growth performance. However, further extensive studies are needed to explore the effects of melatonin on growth performance.

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