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SHORT COMMUNICATION

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Melatonin implantation during the non-growing period of cashmere increases the cashmere yield of female Inner Mongolian cashmere goats by increasing fiber length and density

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Abstract

This study aimed to evaluate if melatonin implantation at the end of April and June was able to increase cashmere production in female Inner Mongolian cashmere goats and to search for contributing factors accounting for the melatonin increasing in cashmere production. One hundred and fifty female Inner Mongolian cashmere goats (initial body weight 37.2 ± 3.3 kg) were randomly assigned to either a control (n=75) or a treatment (n=75) group. Goats in the treatment group were implanted with melatonin (2 mg/kg of body weight) on April 30 and June 30, 2014 while goats in the control received no treatment. Melatonin implantation increased cashmere yield by 23.4% while increasing the length and density of the cashmere fiber by 19.8% and 11.4%, whereas it decreased cashmere fiber diameter by 4.4%. Melatonin treatment had no effect on doe growth, litter size or birth and weaning weights of kid. Melatonin implantation promoted cashmere yield by increasing fiber length and density without impacting the performance of goats and their offspring. Therefore, melatonin implantation during the cashmere non-growing period (late April and June) is an effective way to increase cashmere yield and improve cashmere characteristics of goats.

Additional keywords: cashmere goats; cashmere yield; fiber length; fiber density; melatonin.

Abbreviations used: BW (body weight).

Authors' contributions: Analyzed the data: ZYW, YL, TD and CHD. Conceived and designed the experiments: ZYW, FM and WZ. All authors read and approved the final manuscript.

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Introduction

Cashmere is a highly desirable textile and is usually used to produce luxurious textile products (McCarthy, 1998). China is the largest cashmere producer in the world producing over 19 million kg in 2015 with 44% coming from the Inner Mongolian Autonomous Region (China Statistical Press, 2016). The Inner Mongolian cashmere goat is one of the world's most renowned cashmere goat breeds known for its premium quality of cashmere (Liu *et al.*, 2007).

Cashmere growth exhibits a seasonal rhythm (Dicks *et al.*, 1994; Klören & Norton, 1995; Santiago-Moreno *et al.*, 2004). Research has shown that melatonin is a critical intermediary between photoperiod and cashmere growth with circulating melatonin levels directly affecting cashmere growth (Teh *et al.*, 1991; Klören & Norton, 1995).

In recent investigations (Duan *et al.*, 2015, 2016), it has been found that the administration of exogenous melatonin during the non-growing period of cashmere growth (in late April and late June) altered the timing of the cashmere growth cycle by inducing earlier cashmere growth. When non-half-sib female goats were implanted with melatonin in late April and June, the yield of cashmere and length of cashmere fiber were increased by 20.3% and 15.7% while melatonin implantation in June alone had no effect. Also, it was showed that melatonin implantation (in late April and June) of half-sib female goats increased the cashmere yield and length of cashmere fiber by 34.5% and 21.2%.

These findings represented a great breakthrough in the field of the melatonin regulating of cashmere growth. However, a limitation of these studies was that they involved only a small number of animals, and the proportion of increasing in cashmere yield is higher than that of the cashmere length. Further study is required to verify if melatonin implantation has beneficial effects on cashmere production using larger number of goats. Therefore, the aim of the present study was to evaluate if melatonin implantation at the end of April and June was able to increase cashmere production in female Inner Mongolian cashmere goats and to search for contributing factors accounting for the melatonin-induced increase in cashmere production.

Material and methods

This experiment was conducted from April 30, 2014 to April 26, 2015 on the YiWei White Cashmere Goat Farm located in the Inner Mongolia Autonomous Region of China (Latitude 38°18'N~40°11'N, Longitude 106°41'E~108°54'E, Altitude 1,304 m). All procedures of this study were approved by the Animal Care and Use Committee of China Agricultural University (Beijing, China).

All goats were kept on the grassland throughout the experimental period. Goats were supplemented with a concentrate feed (70% corn and 30% condensed feed purchased from Jiuzhoudadi Biotech Company, Baotou, China), from January to June, in order to meet their nutritional needs during pregnancy and lactation. The amount of concentrate fed per goat was 0.27 kg/d in January and it was gradually increased to 0.4 kg/d in April and to 0.55 kg/d in May and June.

One hundred and fifty Inner Mongolian cashmere goats (weighing 37.2 ± 3.3 kg of body weight (BW)) were randomly assigned to either a control (n=75) or treatment (n=75) groups based on their initial BW, the last year cashmere yield and age. The cashmere produced in the previous year was removed with a comb prior to the experiment. On April 30 and June 30, 2014, melatonin microcapsules (Beijing Kangtai Biological Technology Company, Beijing, China) were subcutaneously implanted at the base of one ear of goats in the treatment group. The melatonin dosage (2 mg/kg BW) was based on the prior works of Duan *et al.* (2015, 2016). Control goats received no treatment.

Cashmere growth was monitored from the start of the experiment. On April 26, 2015, a patch of fleece (3 cm × 3 cm) was shorn from the left scapulae of each goat at the skin level for analysis of fiber length and diameter. At the same time, nine goats were randomly selected from both the control and treatment groups and a patch of fleece (2 cm × 2 cm) was shorn from the right scapulae of each goat in order to measure cashmere density. Cashmere was harvested and weighed using an electronic scale on April 26, 2015 and the weight of the combed cashmere was used to estimate cashmere yield. After cashmere harvest, all of the goats were weighed to record their final BW. The number of kids and their individual birth and weaning BWs were obtained from the breeding records of the Cashmere goat farm.

The cashmere fiber samples were soaked overnight in a carbon tetrachloride detergent solution and then rinsed thoroughly in distilled water and dried at 80°C. One hundred cashmere fibers were randomly chosen from each goat to measure the stretched length of the cashmere fiber using a scaled ruler. Additional cashmere fibers (n ≥ 300), from each goat, were randomly chosen to measure the cashmere diameter using an Optic Fiber Diameter Analyzer (CU-6, Beijing United Vision Technical Company, Beijing, China). The collected cashmere fiber samples were individually weighed using an electric scale. Approximately one-fifth of the fiber samples were then randomly selected from each goat to measure their actual weight. Finally, the cashmere density was calculated following the procedures of Wang *et al.* (2012), using the equation:

$$M = m * (W/W1) * S$$

where M, cashmere density (fibers/cm^2); m, number of fibers in one fifth of the fiber samples; W, full weight of the fiber samples (g); W_1, weight of one fifth of the fiber samples (g); S, sample area (cm^2).

The data were analyzed using the t-test procedure of SAS. Differences were considered significant at $p < 0.05$.

Results and discussion

In the control group, cashmere began to grow at the end of August while the growth of cashmere started at the end of June for the treatment group, indicating that melatonin implantation triggered an earlier cashmere growth of approximately two months. Cashmere shedding occurred in the neck of several goats in the treatment group in late December. The cashmere shedding did not last for long. No apparent cashmere shedding was observed for the remaining goats in treatment until April 26, 2015 when the cashmere was harvested.

The effect of melatonin treatment on doe BW gain is presented in Table 1. There was no significant difference in average daily gain or the initial and final BW of goats between the two treatments ($p > 0.05$). The result is consistent with findings of Duan *et al.* (2015,

Table 1. Effects of melatonin implantation on the growth of Inner Mongolian cashmere goats

Item	Treatment		SEM[a]	*p*-values
	Melatonin	Control		
Initial body weight (kg)	38.2	36.8	0.89	0.14
Final body weight (kg)	37.3	36.6	0.75	0.33
Average daily gain (g)[2]	-2.3	-0.7	1.74	0.36

[a]SEM = standard error of the mean (n=75). The number of experimental days were 365.

2016), melatonin implantation had no apparent effect on the performance of goats when evaluated by BW or average daily gain throughout the study period.

The effects of melatonin treatment on cashmere yield, density, fiber length and fiber diameter is shown in Table 2. The average yield and length of cashmere in melatonin-treated goats was greater than that of the control with a 23.4% and 19.8% increase ($p < 0.01$). These results are consistent with findings of Duan *et al.* (2015, 2016).

Compared with the control, melatonin decreased the cashmere diameter by 4.4% ($p < 0.01$). It would confirm previous results where melatonin treatment of half-sib cashmere goats significantly decreased the fiber diameter of cashmere by 4.1% (Duan *et al.*, 2015). However, these results contradict another prior study in which melatonin implantation of non-half-sib female goats had no effect on the diameter of cashmere fiber (Duan *et al.*, 2016). Other studies have indicated that melatonin treatment did not affect the fiber diameter of Inner Mongolian cashmere goats (Yue *et al.*, 2007; Chang, 2010) and the reason could be that the sample size for each group, in the current study, was 75 which is much larger than the sample size ($n \leq 10$) of those studies. It is well known that statistical power increases with sample size. The large sample size in the present study increased our ability to detect significant differences justifying our desire to revisit this issue with a much larger number of animals.

The results of the present study showed that melatonin implantation during the cashmere non-growing period increased the cashmere yield to a greater extent than the increase in the length of the cashmere fiber. This finding is in line with the results from studies of Duan *et al.* (2015, 2016), suggesting that other factors may also be responsible for the increased cashmere yield induced by melatonin. Further analysis of cashmere samples revealed that the density of cashmere in treatment was significantly increased by 11.4% ($p = 0.01$). Collectively, our results clearly indicate that melatonin implantation during the cashmere non-growing period improved the cashmere yield of Inner Mongolian cashmere goats through at least the combination of increasing the length and density of cashmere with the former being the major player.

The effect of melatonin treatment on doe reproductive performance and kid growth is presented in Table 3. Melatonin administration had no effect on the percentage of does kidding and the litter size of female goats ($p > 0.05$). In addition, it had no effect on the birth or weaning BW of kids ($p > 0.05$). These results are in agreement with some prior findings of Chang (2010) and Duan et al (2015, 2016) but they contradict other studies. For example, melatonin implantation during estrus increased litter size compared with the control in Spanish (Wuliji *et al.*, 2003) and Syrian goats (Papachristoforou *et al.*, 2007). The discrepancy in the effect of melatonin on litter size between these studies may be attributable to the different periods when melatonin was implanted (anestrous period for

Table 2. Effect of melatonin implantation on cashmere production and fiber characters of Inner Mongolian cashmere goats.

Item	Treatment		SEM[c]	*p*-values
	Melatonin	Control		
Fiber length (cm)[a]	10.8	9.0	0.13	<0.01
Fiber diameter (μm)[a]	14.3	15.0	0.12	<0.01
Cashmere density (fibers/cm^2)[b]	3460.6	3106.1	88.83	0.01
Cashmere yield (g)[a]	778.6	630.9	22.87	<0.01

[a] Values are means of 75 replicates per treatment. [b] Values are means of 9 replicates per treatment. [c]SEM = standard error of the mean

Table 3. Effect of melatonin implantation on doe reproductive performance and body weight gain of kids

Item	Treatment		SEM[a]	*p*-values
	Melatonin	Control		
Number bred	75	75		
Number kidding	58	53		
Kidding rate (%)	77.3	70.7	7.19	0.36
Litter size	0.8	0.8	0.08	0.78
Birth weight of kids (kg)	2.8	2.7	0.07	0.21
Weaning weight of kids (kg)	19.4	20.2	0.85	0.34

[a]SEM = standard error of the mean.

the present study *vs.* estrus period previously). In Spanish goats, melatonin implantation had no effect on birth weight and weaning weight of kids which is in agreement with our results (Wuliji *et al.*, 2003).

It is worth noting that we have observed substantial variation in the mean litter size among four studies conducted by us involving Inner Mongolian cashmere goats. The mean litter size was 0.74 for the present study and 0.78 for the study of Chang (2010), while Duan *et al.* (2015, 2016) reported a higher litter size of 1.07. These experiments were all conducted in the same goat farm and the pasture used for the present study was the same one where Duan *et al.* (2015, 2016) conducted their studies. The difference in the mean litter size among these studies may be due to the nutritional status of the experimental goats secondary to the corresponding annual rainfall which occurred during the experimental period. When compared with Duan *et al.* (2015, 2016), the rainfall in the present study was much lower from May through July, a period when the rainfall has a significant effect on the pasture condition in Inner Mongolia (Li *et al.*, 2014). In a four-year study using Merino sheep, researchers found that annual rainfall was the major factor influencing litter size and had a strong correlation with the nutritional status of ewes (Arrebola *et al.*, 2009).

In the present study, goats lost BW as opposed to the average daily gain observed by Duan *et al.* (2015, 2016), providing indirect evidence supporting a poorer nutritional status of the experimental goats in the present study which were grazing on a less desirable pasture due to the lower rainfall. The poorer nutritional status of the goats likely led to their weight loss and a lower litter size. In addition, the poorer nutritional status might also have resulted in the early sporadic cashmere shedding in late December observed in the melatonin implanted group. Therefore, extra attention should be paid to ensure adequate nutritional status of goats when melatonin is applied during practical production.

In summary, melatonin implantation (2 mg/kg BW) on two times (in late April and late June) is an effective way to boost the cashmere yield of female Inner Mongolian cashmere goats and improves cashmere characteristics such as longer and finer cashmere fibers. The increase in cashmere yield by melatonin is largely attributable to the increased fiber length while an increase in the density of cashmere may also play a role in the higher cashmere yield obtained. Melatonin treatment has no effect on doe growth or reproductive performance. Therefore, melatonin administration can be considered as a feasible technique to be applied under commercial goat production.

References

Arrebola FA, Abecia JA, Forcada F, Garcia A, Martibin RA, Mesa O, 2009. Effects of annual rainfall and farm on lamb production after treatment with melatonin implants in Merino sheep: A 4–year study. New Zeal Vet J 57: 141-145. https://doi.org/10.1080/00480169.2009.36893

Chang ZL, 2010. Study on the effect of constant-release melatonin implants on the cashmere growth traits of cashmere goats and related genes. Doctoral thesis. Inner Mongolia Agricultural University, Hothot, China. 50 pp.

China Statistical Press, 2016. China Statistical Yearbook. China Statistical Press, Beijing, China.

Dicks P, Russel A, Lincoln GA, 1994. The role of prolactin in the reactivation of hair follicles in relation to moulting in cashmere goats. J Endocrinol 143: 441-448. https://doi.org/10.1677/joe.0.1430441

Duan CH, Xu JH, Sun CM, Jia ZH, Zhang W, 2015. Effects of melatonin implantation on cashmere yield, fiber characteristics, duration of cashmere growth as well as growth and reproductive performance of Inner Mongolian cashmere goats. J Anim Sci Biotechnol 6: 463-468. https://doi.org/10.1186/s40104-015-0023-2

Duan CH, Xu JH, Zhang Y, Jia ZH, Zhang W, 2016. Melatonin and cashmere growth in Inner Mongolian cashmere goats. Can J Anim Sci 96: 108-113. https://doi.org/10.1139/cjas-2015-0018

Klören WRL, Norton BW, 1995. Melatonin and fleece growth in Australian cashmere goats. Small Rumin Res 17: 179-185. https://doi.org/10.1016/0921-4488(95)00659-9

Li SY, Liu ZL, Chang Y, Ren LJ, Wang R, Wu XX, Fan, Q, 2014. The stability and compensation of the primary productivity of the typical steppe in Inner Mongolia. J Arid Land Res Environ 28: 1-8.

Liu HY, Li N, Jia CL, Zhu XP, Jia ZH, 2007. Effect of the polymorphisms of keratin associated protein 8.2 gene on fibre traits in Inner Mongolia cashmere goats. Asian-Aust J Anim Sci 20: 821-826. https://doi.org/10.5713/ajas.2007.821

McCarthy BJ, 1998. Specialty animal fibres. Textiles 1: 6-8.

Papachristoforou C, Koumas A, Photiou C, 2007. Initiation of the breeding season in ewe lambs and goats kids with melatonin implants. Small Rumin Res 3: 122-126. https://doi.org/10.1016/j.smallrumres.2006.12.004

Santiago-Moreno J, López-Sebastián A, Del Campo A, González-Bulnes A, Picazo R, Gómez-Brunet A, 2004. Effect of constant-release melatonin implants and prolonged exposure to a long day photoperiod on prolactin secretion and hair growth in mouflon (Ovis gmelini musimon). Domest Anim Endocrinol 26: 303-314. https://doi.org/10.1016/j.domaniend.2003.12.004

Teh TH, Jia ZH, Ogden, KD, Newton GR, 1991. The effects of photoperiod and melatonin implant on cashmere production. J Anim Sci 69 (suppl 1): 496.

Wang JY, Zhao XF, Song HN, Liang JW, Wang HT, Niu ST, Tian FL, 2012. Study on coat density of Arctic Fox in the winter fur growth period. Spec Wild Econ Plant Res 3: 6-9.

Wuliji T, Litherland A, Goetsch AL, Sahlu T, Puchala R, Dawson LJ, Gipson T, 2003. Evaluation of melatonin and bromocryptine administration in Spanish goats: I. Effects on the out of season breeding performance in spring, kidding rate and fleece weight of does. Small Rumin Res 49: 31-40. https://doi.org/10.1016/S0921-4488(03)00055-5

Yue CW, Zhang W, Kong XH, Liu HY, Jia ZH, 2007. Effect of melatonin on cashmere performance in Inner Mongolia white cashmere goats. Chin J Anim Sci 43: 32-34.