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CHARACTERISTICS OF ANGORA RABBIT FIBRE 2 -THE INFLUENCE OF THE METHIONINE CONTENT IN FEED AND OF THE ENVIRONMENTAL TEMPERATURE ON FIBRE AND MEDULLA DIAMETER IN ANGORA WOOL

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ABSTRACT : The influence of different environmental factors on the Angora wool quality was determined whilst investigating the effect of the methionine content in feed and of the environmental temperature on fibre and medulla diameter.
The supplementation of DL-methionine increases the mean fibre diameter of female Angora rabbits from 12.5 to 14.4 µm and that of males from 13.2 to 13.9 µm. It is shown that females respond more (1.9 µm mean increase in fibre diameter) to methionine supplementation than males (0.7 µm increase). The response in medulla diameter is similar to that of the fibre diameter in females, i.e. medulla diameter increases (1 µm increase) when additional methionine is supplied. DL-methionine supplementation, however, was not observed to influence medulla diameter in males. Fibre and medulla diameter investigated in fleeces of castrates (14.3 µm and 5.8 µm) is equal to those of the females (14.4 µm and 5.8 µm) in the group offered the higher methionine diet.
Fibre characteristics are also strongly influenced by climatic conditions. Raising the environmental temperature reduces fibre and medulla diameter in Angora rabbit fleeces. The highest fibre and medulla diameters was observed in animals maintained at a temperature of + 5 °C (14.4 µm and 5.7 µm, respectively). Fibre and medulla diameters were reduced in animals kept at + 18 °C (13.6 µm and 5.1 µm, respectively) and were finest at temperatures of + 30 °C (13.0 µm and 4.7 µm, respectively).

RESUME : Caractéristiques du poil de lapin angora.
2 - Influence de la teneur en méthionine de l'aliment et de la température ambiante sur la fibre et le diamètre médullaire du poil de lapin angora.
Après avoir défini l'influence de différents facteurs environnementaux sur la qualité du poil Angora on a recherché l'influence du taux de méthionine de l'aliment et de la température ambiante sur la fibre et le diamètre médullaire. La supplémentation en DL-Méthionine (+0,3% à 0,4% de l'aliment) augmente le diamètre moyen du poil des lapines Angora de 12,5 à14,4 µm et celui du poil des mâles de 13,2 à 13,9 µm ce qui montre que les femelles répondent mieux à la supplémentation en méthionine (+1,9 µm en moyenne) que les mâles (+ 0,7 µm en moyenne). Concernant le diamètre médullaire, la réponse des femelles supplémentées en méthionine est une augmentation de 1µm, alors qu'aucune augmentation n'est observée chez les mâles supplémentés en méthionine. Les diamètres respectifs du poil et de sa moelle dans la toison des mâles castrés (14,3 µm et 5,8 µm) sont équivalents à ceux des femelles (14,4 µm et 5,8 µm) dans le groupe ayant reçu l'aliment contenant le taux le plus élevé de méthionine.
Les caractéristiques du poil sont aussi fortement influencées par les conditions climatiques. L'élévation de la température ambiante diminue le diamètre du poil et celui de sa moelle dans la toison des lapins Angora. Les valeurs les plus élevées ont été obtenus chez des lapins maintenus à + 5°C (14,4µm et 5,7µm, respectivement) tandis que chez des lapins maintenus à + 18°C on obtient des valeurs inférieures (13,6 µm et 5,1 µm) et des valeurs encore plus faibles (13,0 µm et 4,7 µm) chez des lapins maintenus à + 30°C

INTRODUCTION

Wool yield and the development of the fleece properties are generally affected by variations in the nutrient supply to the follicles. The nutrient intake influences primarily the fibre density by affecting the number of follicles (DEVENDRA and COOP, 1982). The strength of fibres and their growth rate are particularly sensitive to the amounts and proportions of amino acids available to the follicle (REIS, 1979). The sulphur containing amino acids are especially responsible for the stimulation of wool growth. While the major sulphur containing amino acid required for the synthesis of wool proteins is cystine, methionine is equally effective for stimulating wool growth (REIS, 1979, 1989, REIS *et al.*, 1992).

The yield of German Angora rabbits could be increased in the past by improving the feeding conditions, including higher supplementation with thioamino acids (KETTNER, 1962; SCHEPENS, 1968). Comprehensive studies on Angora rabbits were undertaken by SCHLOLAUT (1984) and SCHLOLAUT and LANGE (1973, 1983) to investigate the influence of methionine supplementation on wool yield, fodder utilisation, fattening performance and fertility. It was observed that supplementation with DL-methionine increases the wool yield and decreases the feed conversion efficiency.

Fibre yield and quality are also influenced by environmental conditions. KETTNER (1962) observed in investigations on the wool yield of Angora rabbits that unusually warm and dry summers result in low autumn wool yields, whilst cold and wet conditions in summer do not depress the wool yield to the same extent. Angora rabbits yield lower amounts of wool in relatively warm winters compared to colder ones. Finer wool is produced under warmer conditions (FRÖHLICH, 1969).

STEPHAN *et al.* (1979) and DOPPLER *et al.* (1984) observed that the higher the environmental temperature, the lower the wool yield is in Angora rabbits which is related to the higher fibre density and the longer fibres in colder compared to warmer climates. The extent to which this effect is dependent on temperature alone or on other environmental components, such as day length is unknown.

In various studies it is shown that a methionine supplementation (SCHLOLAUT, 1984; SCHLOLAUT and LANGE, 1973, 1983) as well as a decreased environmental temperature (STEPHAN *et al.*, 1979; DOPPLER *et al.*, 1984) yields in a higher wool yield in Angora rabbits. The consideration of the effects of environmental components, however, is essential for the wool production potential, i. e. the wool yield as well as the wool quality of Angora rabbits. The present study deals with detailed investigations of the influence of the methionine content in feed and of the climatic conditions on Angora wool quality. It is examined to what extent the specific wool characteristics: fibre and medulla diameter differ whilst increasing the methionine content in feed and whilst raising the environmental temperature.

MATERIAL AND METHOD

The feeding experiment was carried out at the Hessen Institute of Animal Breeding (Hessische Landesanstalt für Tierzucht) in Neu-Ulrichstein. Angora rabbits of the German origin were used.

Three males, one of which was castrated, and two females were selected from each of ten litters, to establish

Table 1 : Fibre and medulla diameters in Angora rabbit wool under different feeding conditions. Descriptive parameters

	Fibre diameter		Medulla diameter	
sex / group	$\bar{x}$ in µm	s in µm	$\bar{x}$ in µm	s in µm
Males/Group I	13.2	2.87	5.5	2.09
Males/ Group II	13.9	3.47	5.7	2.59
Females/Group I	12.5	2.38	4.8	1.71
Females/Group II	14.4	3.19	5.8	2.20
Castrates/Group II	14.3	2.99	5.8	2.09

($\bar{x}$ - arithmetic mean, s - standard deviation)

Table 2 : Differences in wool diameters and their levels of significance

	Fibre diameter differences in µm	Significance level Tukey test
Males/Group I - Males/Group II	0.7	< 0.001
Females/Group I - Females/Group II	1.9	< 0.001
Males/Group I - Females/Group I	0.7	< 0.001
Males/Group II - Females/Group II	0.4	> 0.05

five sets of ten animals each. These five sets were divided between two feeding groups:

Group I received commercial all-mash rabbit feed (containing 0.5% methionine, 0.27% cystine and 0.71% lysine) and Group II received commercial all-mash rabbit feed supplemented with 0.3 - 0.4 % DL - methionine.

Group I contained 10 males and 10 females, Group II contained 10 males, 10 females and 10 castrates. The trial started when the animals were 8 weeks old. The rabbits had access to feed limited to 5 hours per day. They were shorn every 91 days. The fleece samples for analysis were taken from all the animals (N = 50) from the left shoulder position at the end of the fourth shearing interval.

The second trial was organised and conducted by the Hessen Institute of Animal Breeding in collaboration with the Faculty of Veterinary Medicine of the University of Hannover. It was aimed at the evaluation of differences in the wool growth and feed and water intake under different environmental conditions of German angora rabbits.

A group of 10 males was kept under three different temperature/air humidity and constant lighting conditions during the following three consecutive shearing intervals:

I. + 5 °C / 80 %
II. + 18 °C / 70 %
III. + 30 °C / 60 %

Each animal spent 13 weeks (one shearing period) in each treatment. Wool samples were obtained from the right shoulder at the end of each shearing interval.

Fibre diameter is generally affected by age. With increasing age, fibres become coarser (SHELTON, 1980; GIFFORD *et al.*, 1990; PATTIE and RESTALL, 1990). To overcome the influence of age on the fibre development in the course of the experiment, the animals were kept initially in the coldest and finished in the warmest climate chamber.

Table 3 : Fibre and medulla diameter in Angora rabbit wool under different environmental conditions. Descriptive parameters

Climatic	Fibre diameter		Medulla diameter	
conditions	$\bar{x}$ in µm	s in µm	$\bar{x}$ in µm	s in µm
I. + 5 °C	14.4	3.00	5.7	2.07
II. + 18 °C	13.6	2.76	5.1	1.78
III. + 30 °C	13.0	2.61	4.7	1.54

The basis of sample preparation and measurement was IWTO-8-89(E). 300 fibres of each sample were measured, applying the microprojection method to determine fibre and medulla diameter. The measurements were carried out 1 cm above the base of the hairs. Results were subjected to analysis of variance and differences between means were determined using the Tukey-test.

RESULTS

The influence of the methionine content in feed on the fibre and medulla diameter in Angora wool

The supplementation of DL-methionine increased the fibre diameter of females from 12.5 to 14.4 µm and that of males from 13.2 to 13.9 µm. Most of the differences in mean fibre diameter between the groups were statistically highly significant. One exception was the difference between the females (14.4 µm) and bucks (13.9 µm) in Group II. The descriptive parameters of the fibre diameter investigation are summarised in Table 1; the differences in mean fibre diameter and their significance levels are illustrated in Table 2.

In Group I, the fibre diameter of males was higher than that of females. Down fibre diameter increased in both sexes when given additional thioamino acid. This effect was more pronounced in females compared to the bucks, so that in Group II, female mean fibre diameter exceeded that of the males. The differences in mean fibre diameter between the sexes of Group II, however, did not reach statistical significance.

The response in medulla diameter was similar to that of the fibre diameter (Table 1). The medulla diameter increased from 4.8 µm (Group I) to 5.7 µm (Group II) in females. However, DL-methionine supplementation was not observed to influence medulla diameter in males (5.5 µm in Group I vs. 5.8 µm in Group II). In Group II, the medulla diameters of males and females were similar (5.7 µm in males vs. 5.8 µm in females).

Fibre and medulla diameters of castrates (Group II) were equal to those of the females (14.3 - 14.4 µm and 5.8 µm, respectively). The comparison of castrated and uncastrated males, in Group II, shows that the castrates have higher mean fibre and medulla diameter values than the uncastrated animals. The fibre diameter differences were statistically significant at the $p < 0.001$ level, the medulla diameter differences were significant at the $p < 0.05$ level.

The influence of the environmental temperature on fibre and medulla diameter in Angora wool

The influence of different environmental temperatures on fibre and medulla diameter in Angora rabbit wool is presented in Table 3.

In Table 3 it is shown that both the fibre and medulla diameter in Angora wool is reduced with increasing the ambient temperature. The highest fibre and medulla diameters were observed in animals maintained at a temperature of +5°C (14.4 µm and 5.7 µm). Inner and outer fibre diameters were reduced in animals kept at + 18 °C (13.6 µm and 5.1 µm) and were finest at temperatures of + 30 °C (13.0 µm and 4.7 µm). All of the differences in the fibre and medulla diameter between the climatic stages, were statistically significant at the $p < 0.001$ level. The reduction in fibre and medulla diameter in Angora rabbits with increasing environmental temperature is illustrated in Figures 1 and 2.

DISCUSSION

Nutrition is one of the most important factors influencing Angora wool production. It is observed that higher dietary methionine intake increases the fibre diameter of Angora wool in both sexes. DOEHNER (1953) observed similar results for sheep's wool, SAHLU and FERNANDEZ (1989, 1992) and SHELTON and HOUSTON (1966) for Angora goat hair. Females responded more (1.9 µm mean increase in fibre diameter) to methionine supplementation than males (0.7 µm increase).

The interaction between the factors, sex and feeding group, was noteworthy. In Group I, it was shown that the mean fibre diameter in males was higher than that of females. The supplementation with DL-methionine (Group II) increased the mean fibre diameter in both sexes. This effect was more pronounced in females compared to males, so that female mean fibre diameter exceeded that of bucks in Group II. These differences, however, did not reach statistical significance.

Female Angora rabbits are generally able to produce 30% (5 - 30 %) more wool than males (DOPPLER *et al.*, 1984). MAGOFKE *et al.* (1982) observed differences in wool production of 2 - 22 %. SCHLOLAUT and LANGE (1983) commented that the influence of DL-methionine supplementation on wool growth is greatest in animals with the highest performance potential. Females can therefore derive more advantage from supplementation than bucks. The differences in the wool performance potential is mainly related to differences in the physique and weight between the sexes. The larger and heavier females have a higher feed intake. This is possibly an explanation for the greater increase in mean fibre diameter observed in females in comparison to males.

In Group I, a higher mean fibre diameter in males compared to females was observed. This could be related to the influence of androgen hormones in males. This is, however, in contradiction to earlier observations. For instance, DOTTERWEICH (1942) and HOHLS (1950) reported female Angora rabbits to have the greater fibre diameter.

A similar effect was observed in the influence of methionine supplementation on medulla formation. The medulla diameter of males was higher than that of females in Group I. An increase in methionine content in feed evened out the differences between sexes. Likewise, medulla diameter increased more in females than in males.

Because of the inferior reproductive performance of Angora in comparison with normal haired rabbits, the use of all progeny for wool production is necessary (SCHLOLAUT and LANGE, 1983). To improve wool growth in males, the animals must be castrated. In the present study, the castrates belonged to Group II. With castration and supplementation with DL-methionine, fibre and medulla diameter was similar to the females in the same group.

SCHLOLAUT (1976) and SCHLOLAUT and LANGE (1973, 1983) reported that supplementation with DL-methionine increases wool growth and reduces feeding costs per 100 g fibre. Likewise, the addition of thioamino acid results in an increase in fibre and medulla diameter.

Finer fibre tends to be more prone to felt formation, because of its denser fleece structure. Development of thicker

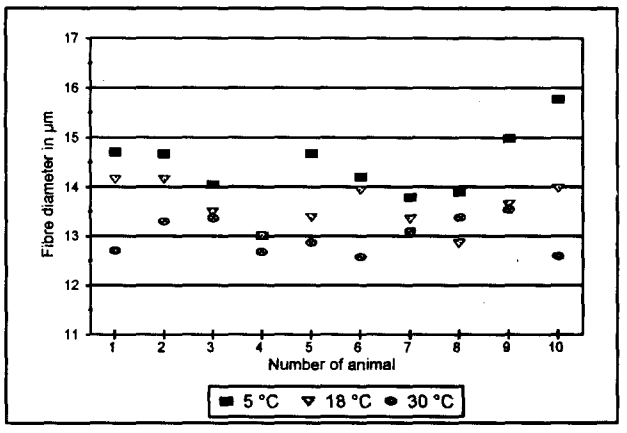

Figure 1 : Fibre diameter under different climatic conditions - Changes in individual animals -

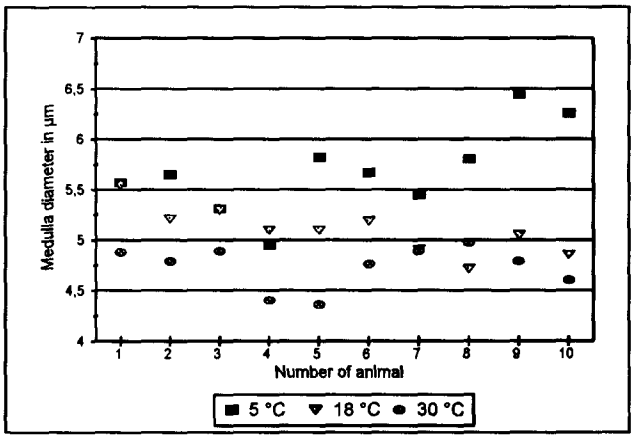

Figure 2 : Medulla diameter under different climatic conditions- Changes in individual animals -

wool fibres should improve fleece quality by reducing this tendency (NIEHAUS, 1955; KETTNER, 1962).

Both fibre and medulla diameter increase through methionine supplementation. The inner diameter, however, does not increase to the same extent as the outer diameter. The cortex layer is therefore thicker in both sexes in Group II (8.3 µm for males, 8.6 µm for females) in comparison with Group I (7.7 µm for males, 7.7 µm for females).

SCHLOLAUT *et al.* (1987) observed that the differences in tensile strength are related to the higher number of air chambers in the hair. The fibres of animals belonging to Group II must therefore have a higher tensile strength, because the medulla diameter is smaller in relation to the fibre diameter. If the difficulties encountered in dyeing processes were only related to the absolute fibre diameter, the wool of the animals in Group II would cause more problems.

It is generally shown that a methionine supplementation affects the fibre quality of Angora wool decisively. To what extent these morphological changes have actually an influence on the processing capability of this wool has to be investigated in further experiments.

Fibre characteristics are also strongly influenced by environmental conditions. Angora rabbits have special requirements with regard to the avoidance of temperature stress. Temperature stress involves, on the one hand, a lack of heat protection after shearing and, on the other hand, the increased difficulty to lose the waste heat of metabolism, because of the long fleece present between the 5th and 6th week after shearing (SCHLOLAUT, 1986).

Raising the environmental temperature causes a reduction in fibre yield (STEPHAN *et al.*, 1979; DOPPLER *et*

al., 1984; SCHLOLAUT, 1986). Fibre yield is always higher in cooler than in warmer seasons, because fibre density and length are both increased in cold climates (STEPHAN *et al.*, 1979; DOPPLER *et al.*, 1984; ROCHAMBEAU and THEBAULT, 1990).

Previous authors have found that low temperatures increase fibre diameter and, conversely, warmer conditions result in finer wool (TÄNZER, 1933; FRÖHLICH, 1969). This is in accordance with the present investigations, which show that raising the environmental temperature, reduces fibre and medulla diameter. A temperature of + 5 °C leads to diameter values of 14.4 µm and 5.7 µm respectively, that of + 30 °C to 13.0 µm and 4.7 µm respectively.

High temperatures restrict food intake in Angora rabbits (STEPHAN *et al.*, 1979). This leads to a reduction in hair growth and ultimately to a decrease in fibre yield. However, less feed is required for heat production to maintain body temperatures in the first week after shearing. Consequently, higher environmental temperatures result in less expenditure on feed per kg wool produced.

Because warmer climatic conditions improve the balance between feeding costs and fibre value, Angora rabbit production is especially favoured by warmer climates (tropical or subtropical regions) (STEPHAN *et al.*, 1979). As Angora wool production is a labour-intensive enterprise because of the necessity to keep animals in individual cages and because of the harvesting methods employed, it has advantages, especially in tropical or subtropical regions, related to the low cost of labour compared to those in developed countries (SCHLOLAUT, 1988). It can be assumed that the change in Angora wool quality, i. e. the reduction in fibre diameter in animals raised at higher temperatures is not detrimental to processing of the scoured material, as modern finishing processes are available in the textile industry.

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