EFFECT OF DAY LENGTH ON FATTY ACID CONTENT OF SHEEP WOOL FAT

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Abstract

Wool is a natural material obtained from sheep. An essential ingredient of sheep wool is lanolin, also known as wool wax, whose sweat fraction consists of organic acids and aqueous salts, while the fat fraction is composed mainly of fatty acids. Lanolin is used in the pharmacological industry as well as in cosmetics. Since sheep are seasonal animals, their productivity is regulated by the length of day. Therefore, the present study was undertaken with the aim of determining the effect of day length on fatty acid content in wool. Twenty Polish Longwool sheep were used in the study. Wool was sampled from each sheep in May (long-day period) and December (short-day period) at the shoulder, flank and rump. Subsequently, the wool samples underwent biochemical analysis. The Soxhlet method was used for fat extraction, while fatty acids were determined using gas chromatography. The results showed a significant effect of day length on fatty acid content in wool fat. The fat contained in wool fibre samples in December had higher fatty acid content than was the case for samples taken in May.

Keywords: wool, length of day, fatty acids

Introduction

Wool is a natural fibre obtained from sheep. It has good physical and chemical properties, such as a high temperature of ignition (over 550°C) and hygroscopicity. These properties make sheep wool suitable for use in construction and agriculture to produce compound fertilisers (Szatkowski et al., 2021a, b; 2022a, b). An essential ingredient of sheep wool is lanolin, also known as wool wax, composed of two fractions, namely fat and sweat. Sweat is a solution of aqueous salts and organic acids, while fat contains 32-36% esters of higher fatty and wax acids, 22-24% aliphatic alcohols and free fatty acids, 24-33% sterols as well as modest amounts of hydroxy acids and salts. It has a colour ranging from pale yellow to brown (Skoczylas, 1978). Wool wax maintains the wool in a good physiological state, while also having bacteriostatic and lubricating effects (Molik and Potocka, 2019). Lanolin is also used in the cosmetic and pharmacological industries to produce conditioners, hair shampoos, tonic lotions as well as medicinal creams and ointments (Śliwa et al., 2011). Thanks in particular to the presence of unsaturated fatty acids, such as oleic acid, linoleic acid and linolenic acid (CLA), lanolin has a beneficial effect on the skin, forming a protective film on the epidermis, maintaining a constant level of moisture in its outer layers, and preventing it from cracking (Milewski, 2006; Cholewińska et al., 2016, 2018). Day length strongly influences sheep productivity and the quality of wool fibre. Our own research has shown that day length influences wool thickness. Our study has shown that sheep wool is thinnest during the long-day period when there is a high concentration of prolactin. In contrast, during the short-day period, when prolactin concentrations remain low, the wool is thicker (Molik et al., 2019). Changes in the prolactin profile and wool thickness as a function of day length may suggest fluctuations in the content of fat and fatty acids in wool. The objective of this study was to determine the effect of day length on fatty acid content in the wool of Polish Longwool sheep.

Material and methods

Twenty Polish Longwool sheep with uniform coat were selected for the study. Dams were similar in age and body weight. The wool was sampled in May and December. The first wool sampling took place during shearing in May (long-day period) following a 7-month period of regrowth. The second sampling took place in December (short-day period) following a 7-month period of regrowth. Wool samples were each time taken from the left flank, making sure that the cut was made directly at the skin. The first sample was taken from the shoulder area; the second sample was taken in parallel to the first from the flank area and the third from the rump area. Afterwards, the wool was packed into sealed plastic containers and sent out for analysis.

Fibre analyses for the determination of fatty acids

Biochemical analyses were carried out in two stages. In the first stage, fat was extracted from the wool using the Soxhlet method. In the second stage, fatty acids were determined in fat samples using gas chromatography according to the methodology provided by Mann J. (1964). The content of fatty acids was determined: C4:0, C6:0, C8:0, C10:0, C10:1, C12:0, C14:0, C14:1, C15:0, C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2, C18:3, C20:0, C20:1 and CLA.

Statistical analysis

Changes in fatty acid content were analysed using one-way analysis of variance (ANOVA), using Scheffe’s test.

Results

The analysis of the content of saturated fatty acids in the wool sampled from the shoulder, flank and rump showed that the wool contained less fatty acids during the long-day period than the wool sampled during the short-day period (December) (Tables 1, 2, 3).

Table 1. Effect of day length on saturated fatty acid content of wool (sampled from the shoulder)

Kwasy tłuszczowe nasycone (%) Saturated fatty acids (%)	Grupa 1 – pobranie wełny w maju Group 1 – wool sampled in May		Grupa 2 – pobranie wełny w grudniu Group 2 – wool sampled in December	
	x	SD	x	SD
C10:0	1.54	0.03	1.67	0.04
C12:0	1.46[a]	0.02	1.77[b]	0.05
C14:0	5.67[a]	1.12	6.15[b]	0.08
C15:0	1.39[a]	0.01	1.96[b]	0.04
C16:0	22.86[A]	4.34	27.68[B]	4.25
C17:0	0.34	0.01	0.42	0.02
C18:0	18.14[A]	3.12	20.39[B]	5.11

A, B – Means in rows with different letters are significantly different at $P \leq 0.01$.
a, b – Means in rows with different letters are significantly different at $P \leq 0.05$.

Table 2. Effect of day length on saturated fatty acid content of wool (sampled from the flank)

Kwasy tłuszczowe nasycone (%) Saturated fatty acids (%)	Grupa 1 – pobranie wełny w maju Group 1 – wool sampled in May		Grupa 2 – pobranie wełny w grudniu Group 2 – wool sampled in December	
	x	SD	x	SD
C10:0	1.290[A]	0.01	2.314[B]	0.03
C12:0	1.61[a]	0.02	2.24[b]	0.02
C14:0	6.88[A]	0.05	8.23[B]	0.09
C15:0	2.08	0.02	2.84	0.02
C16:0	21.09[A]	3.08	30.18[B]	6.04
C17:0	0.20	0.01	0.31*	0.02
C18:0	17.33[A]	3.28	19.33[B]	4.32

For explanations see Table 1.

Table 3. Effect of day length on saturated fatty acid content of wool (sampled from the rump)

Kwasy tłuszczowe nasycone (%) Saturated fatty acids (%)	Grupa 1 – pobranie wełny w maju Group 1 – wool sampled in May		Grupa 2 – pobranie wełny w grudniu Group 2 – wool sampled in December	
	x	SD	x	SD
C10:0	1.60	0.03	1.91	0.05
C12:0	1.6[a]	0.03	2.09[b]	0.08
C14:0	6.44[a]	1.12	7.65[b]	0.09
C15:0	2.14	0.04	2.27	0.07
C16:0	20.60[A]	2.78	24.25[B]	3.42
C17:0	0.39	0.01	0.57	0.02
C18:0	16.29[a]	2.11	17.29[b]	2.36

For explanations see Table 1.

The analysis of the content of unsaturated fatty acids in wool sampled from the shoulder, flank and rump showed a higher content of these acids during the short-day period (Tables 4, 5, 6). In the wool sampled from the shoulder, significant differences occurred only for tetradecanoic acid (C14:1) and oleic acid (C18:1n-9). The acid content (C14:1) was lower in May ($P \leq 0.05$) (0.23±0.01%) compared to short-day conditions (0.52±0.02%). The oleic acid content (C18:1n-9) was also lower in May ($P \leq 0.01$) (13.80±1.38%) compared to December (15.55±2.34%) (Table 4). The wool sampled from the flank showed significantly more tetradecanoic acid (C14:1) and palmitoleic acid (C16:1n-7) in December (0.55±0.02%, 1.08±0.04%, respectively) than in May (0.22±0.01%, 0.68±0.03%). Wool fibre sampled in December also contained more ($P \leq 0.01$) oleic acid (C18:1n-9) than in May (12.38±2.31, 9.21±1.12%) (Table 5). The wool sampled from the rump showed a lower ($P \leq 0.05$) content of tertradecanoic acid (C14:1) in the long-day period (0.88±0.04%) than in the short-day period (1.87±0.09%). The wool sampled in May contained less ($P \leq 0.01$) palmitoleic acid (C16:1n-7) than the December sample: 0.59±0.02%, 1.58±0.06%, respectively. Considerably more oleic acid ($P \leq 0.01$) (C18:1n-9) was found in the wool sampled in December (13.39±2.31%) in comparison with the May sample (8.39±1.23%). The analysis of the content of vaccenic acid (C18:1n-7) showed a significantly higher content ($P \leq 0.05$) in wool sampled in short-day conditions (1.39±0.08%) compared to wool taken in long-day conditions (0.70±0.06%) (Table 6).

Table 4. Effect of day length on unsaturated fatty acid content of wool (sampled from the shoulder)

Kwasy tłuszczowe nienasycone (%) Unsaturated fatty acids (%)	Grupa 1 – pobranie wełny w maju Group 1 – wool sampled in May		Grupa 2 – pobranie wełny w grudniu Group 2 – wool sampled in December	
	x	SD	x	SD
C14:1	0.23[a]	0.01	0.52[b]	0.02
C16:1n-9	0.32	0.01	0.36	0.01
C16:1n-7	0.93	0.03	0.97	0.02
C17:1	0.10	0.01	0.12	0.01
C18:1n-9	13.80[A]	1.38	15.55[B]	2.34
C18:1n-7	0.99	0.02	1.23	0.08

For explanations see Table 1.

Table 5. Effect of day length on unsaturated fatty acid content of wool (sampled from the flank)

Kwasy tłuszczowe nienasycone (%) Unsaturated fatty acids (%)	Grupa 1 – pobranie wełny w maju Group 1 – wool sampled in May		Grupa 2 – pobranie wełny w grudniu Group 2 – wool sampled in December	
	x	SD	x	SD
C14:1	0.22[a]	0.01	0.55[b]	0.02
C16:1n-9	0.31	0.01	0.36	0.01
C16:1n-7	0.68[a]	0.03	1.08[b]	0.04
C17:1	0.13	0.01	0.25	0.01
C18:1n-9	9.21[A]	1.12	12.38[B]	2.31
C18:1n-7	0.91	0.04	0.60	0.02

For explanations see Table 1.

Table 6. Effect of day length on unsaturated fatty acid content of wool (sampled from the rump)

Kwasy tłuszczowe nienasycone (%) Unsaturated fatty acids (%)	Grupa 1 – pobranie wełny w maju Group 1 – wool sampled in May		Grupa 2 – pobranie wełny w grudniu Group 2 – wool sampled in December	
	x	SD	x	SD
C14:1	0.88[a]	0.04	1.87[b]	0.09
C16:1n-9	0.27	0.01	0.31	0.01
C16:1n-7	0.59[A]	0.02	1.58[B]	0.06
C17:1	0.12	0.01	0.13	0.01
C18:1n-9	8.39[A]	1.23	13.39[B]	2.31
C18:1n-7	0.70[a]	0.06	1.39[b]	0.08

For explanations see Table 1.

The analysis of the content of polyunsaturated fatty acids in the wool sampled from the shoulder showed a significant difference (P≤0.01) in the content of linoleic acid (C18:2n-6), lower during the long-day period (10.14±1.27%) and higher during the short-day period (14.73±3.24%). Similar correlations were recorded for linolenic acid (C18:3(n-6) in May 0.44±0.02% and December 1.04±0.08%, respectively. The content of CLA acid was lower (P≤0.01) in the wool sampled in May (12.27±2.31%) and higher in the second study period (14.55±3.21%) (Table 7).)

Table 7. Effect of day length on polyunsaturated fatty acid content of wool (sampled from the shoulder)

Kwasy tłuszczowe wielonienasycone (%) Polyunsaturated fatty acids (%)	Grupa 1 – pobranie wełny w maju Group 1 – wool sampled in May		Grupa 2 – pobranie wełny w grudniu Group 2 – wool sampled in December	
	x	SD	x	SD
C18:2n-6	10.14[A]	1.27	14.73[B]	3.24
C18:3n-6	0.44[a]	0.02	1.04[b]	0.08
C18:3n-3	0.14	0.01	0.17	0.01
CLA	12.27[A]	2.31	14.55[B]	3.21

For explanations see Table 1.

The wool sampled from the flank showed a higher (P≤ 0.01) linoleic acid (C18:2n-6) content in May (15.7±3.26%) compared to samples taken in December (8.50±2.11%). The same was true for CLA, whose content was higher (P≤ 0.01) in May (17.62±4.22%) and lower in December (12.92±1.26%) (Table 8).

Table 8. Effect of day length on polyunsaturated fatty acid content of wool (sampled from the flank)

Kwasy tłuszczowe wielonienasycone (%) Polyunsaturated fatty acids (%)	Grupa 1 – pobranie wełny w maju Group 1 – wool sampled in May		Grupa 2 – pobranie wełny w grudniu Group 2 – wool sampled in December	
	x	SD	x	SD
C18:2n-6	15,7[A]	3,26	8,50[B]	2,11
C18:3n-6	1,36[a]	0,08	0,74[b]	0,09
C18: 3n-3	0,23	0,01	0,18	0,01
CLA	12,92[A]	1,26	17,62[B]	4,22

For explanations see Table 1.

The analysis of the content of polyunsaturated fatty acids in the rump samples showed a lower (P≤0.01) concentration of linoleic acid (C18:2n-6) in May (14.66±3.21%) than in December (17.05±5.22%). Also, wool sampled during the short-day period contained more (P≤0.01) linoleic acid (C18:3n-6) (0.93±0.08%) than in May (0.36±0.02%). Significantly less (P≤0.05) a-linolenic acid (C18:3n-3) was found in the wool sampled in May (0.18±0.01%) compared to December (0.27±0.01%). For rump wool, the CLA content was significantly higher (P≤0.05) in December (16.76±4.21%) compared to the long-day period (15.00±3.26%)

Table 9. Effect of day length on polyunsaturated fatty acid content of wool (sampled from the rump)

Kwasy tłuszczowe wielonienasycone (%) Polyunsaturated fatty acids (%)	Grupa 1 – pobranie wełny w maju Group 1 – wool sampled in May		Grupa 2 – pobranie wełny w grudniu Group 2 – wool sampled in December	
	x	SD	x	SD
C18:2n-6	14.66[A]	3.21	17.05[B]	5.22
C18:3n-6	0.36	0.02	0.93[**]	0.08
C18:3n-3	0.18[a]	0.01	0.27[b]	0.01
CLA	15.00[a]	3.26	16.76[b]	4.21

For explanations see Table 1.

Discussion

Our study has shown that due to sheep sensitivity to day length the biological characteristics of their wool are affected by that factor. During the short-day period, the wool was characterised by a higher content of saturated fatty acids. Also, wool sampled in December from the shoulder, flank and rump contained more unsaturated fatty acids. A study by Cholewińska et al. (2016) showed that in both lambs and their dams, wool sampled at different times of the year showed different fatty acid contents. Analyses of polyunsaturated acid content in wool sampled from the shoulder and rump showed a higher content of these acids during the short-day period. Only the wool sampled from the flank showed a higher content of polyunsaturated acids, not including the CLA content. A study by Molik et al. (2019) showed that the length of day had a significant effect on wool thickness. Wool sampled in May was thinner than wool sampled in December. Wool thickness and moulting are influenced by changes in prolactin secretion. The study showed that prolactin concentrations in sheep are significantly higher in May than in December, which affects the biological parameters of the wool (Molik et al., 2019). The research presented in this paper showed that the length of day significantly affects fatty acid content in sheep wool. The most favourable composition of these compounds was recorded during the short-day period at a time when most seasonal sheep breeds are sheared. The study showed that in seasonal sheep, day length significantly affects fat and fatty acid content in wool. The wool fat sampled in December (shoulder, flank, rump) showed a higher fatty acid content than was the case for the long-day period. Similar correlations were recorded for unsaturated fatty acids. An important step forward towards the use of wool fat as a component of cosmetics was to determine the content of polyunsaturated fatty acids, especially CLA. Wool fat sampled in December contained more of these fatty acids than that sampled in May. The obtained results may suggest that both prolactin secretion and fatty acid content in wool may be influenced by day length. According to a study by Szczęsna and Zięba (2008), prolactin is involved in fat metabolism and leptin secretion regulation in adipose tissue cells. Metabolic hormone secretion and fat metabolism in seasonal sheep may influence fat content in products depending on the length of the day.

Wool and products derived from it have health-promoting qualities and are consistent with bio-economy and sustainable development strategies (Borys, 2012; Rokicki, 2015; Szatkowski et al., 2021a, b). The research on the influence of environmental factors on wool characteristics may have practical relevance due to the health-promoting qualities of wool and the possibility of its use as a component of cosmetics or in the manufacture of wool products with a wide range of applications.

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