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Fat content and fatty acid profile of milk from farmed canids

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Milk is the first and basic food in the first days of the life of all mammals. The composition of the secretion of mammary gland shows a very wide variation depending on the species, the age of the female, the stage of lactation and the environmental and genetic factors. The secretion of the mammary gland physiologically and structurally corresponds to the newborn's nutritional needs. Each mammal species produces milk of different but specific composition which characteristic of that species. The basic ingredients of milk of all females are fats, protein, lactose and minerals. Milk of a cow, mare or cat dam contains the same groups of ingredients, i.e. it is identical from the qualitative point of view. However, the content of individual milk ingredients is proportionally and quantitatively different (Szulc, 2012). Milk produced during lactation is not identical throughout its duration and varies depending not only on the lactation stage but also on the time of day or even – in the case of one female – which gland it is produced by (Park & Haenlein, 2006). Fat has the highest variability and lactose has the lowest variability among the nutrients contained in milk (Morgan, 2006).

Fat and fatty acids are among the most important substances that regulate the proper development of each mammal in the post-partum period (Barłowska, 2008). These substances are responsible for energy processes that take place in the cell and form the main building blocks of cell membranes. They are also precursors of substances that are important to metabolism, such as prostacyclin or prostaglandin (Kuczyńska & Puppel, 2008). Fat in milk is in the form of microscopic globules with a diameter of approx. 2–8 µm, which form an oil-in-water emulsion (Kordyasz & Kuczyńska, 2012). The structure and composition of a single fat globule are very complex. Fatty acids vary in carbon chain lengths and the number of unsaturated fatty acids (Rutkowska et al., 2015).

The aim of the study was to determine the fat content and the fatty acid profile in the milk of females of farmed finnraccoon and common foxes depending on their origin and lactation stage.

Materials and methods

The research material consisted of milk samples taken from 10 finnraccoon and 10 common fox females in different phases of lactation: I (until the 10th day after whelping), II (between the 11th and the 20th day after whelping) and III (from the 21st day after whelping). The females came from two farms located in the Świętokrzyskie and Podkarpackie voivodeships.

The milk was taken in the morning. Several minutes before samples were taken, the females were given intramuscularly 0.2 mU of oxytocin (Oxytocinum Biowet, Puławy), which activated and accelerated the secretion of milk. The milk was obtained manually into sterile containers and tubes from all active nipples (Fhot. 1). While samples were being taken, efforts were made to empty the milk glands completely so that the samples were representative of the actual composition of the milk ingested by the pups.

The determination of fat content in the milk samples was performed using analysers: Milkoscan FT 2 TYPE 79069 manufactured by

FOSS – near infrared. The fatty acid profile analysis was determined by gas chromatography on a Varian 450-GC apparatus equipped with a FID detector, using a CP-SIL 88 (FAME) column with a length of 100 m and a diameter of 0.25 mm. Fat extraction was carried out by Folch method (1957) using a mixture of chloroform and methanol in a 2:1 ratio. 0.58% of NaCl was then added and centrifuged. 1 cm^3 of the lower layer was taken and the solvent was evaporated using nitrogen (at the temp. of 50°C). 0.5 M NaOH in methanol, 10% BF_3 in methanol and heptane were added one after another to the dry residue. After adding each reagent, the tube was closed and placed in a water bath (73°C). A saturated NaCl solution was then added. After the layers were separated, the heptane layer was removed and placed in a tube containing anhydrous Na_2SO_4. Acid identification was carried out using the Sigma and Grace standards. The statistical analysis was performed to determine the significance of the differences in fat content and individual fatty acids in the milk of the raccoon dogs using the GLM procedure (SAS 2001).

The percentage contents of fat and fatty acids were compared using the Tukey test. The testing was conducted at the level of $P \leq 0.05$.

Results and discussion

The fat content in the milk of the finnraccoon females was 12.46% on average and was higher than that of common fox female's milk, whose average fat content was 10.21% (Tab. 1).

Photo 1. Collection of milk from female finnraccoon

Table 1. Fat content of milk from farmed female finnraccoon and common foxes (%)

Finnraccoon			Common fox		
$\bar{x} \pm SD$	minimum	*maximum*	$\bar{x} \pm SD$	minimum	*maximum*
12.46 ±2.90	7.45	16.41	10.21 ±2.30	7.47	14.30

The data provided in Table 2 shows that farmed canids' milk contains 2–3 times more fat compared to milk of farm animal females. The both females' milk fat had a characteristic form of globules.

In our own research, there was no significant difference in the proportion of individual classes of fat globules between raccoon dogs and common foxes. In the milk of females of both species, the class of the smallest globules <6 µm was the most numerous, while big globules >10 µm were the least numerous.

Table 2. Milk fat percentage in some female farmed and companion animals (Park and Haenlein, 2006; Kuczyńska and Puppel, 2009)

Species					
cow	goat	sheep	mare	botch	kitten
3.4–3.5	4.0–4.1	6.5	1.0–2.3	8–12	4.8–6.8

Fat is the dominant ingredient in the milk of foxes and finnraccoon. The results we obtained are similar to those obtained by Bryla (1989). According to his research, milk fat accounts for 10.3%. The amount of this ingredient in the milk of the raccoon dog is only second to coypu, in which milk fat accounts for more than 28% of the dry matter, according to Kopański (1977). Similar content was found in the milk of the chinchilla (Volcani et al., 1973) and the rabbit (Kowalska, 2000). The fat content of mammalian milk depends primarily on the environment they live in. Sea animals have the richest fat milk. Dolphin's milk has 35% of fat and grey seal and whale have even more than 50% (Jensen et al., 1991).

Table 3. Effect of stage of lactation on milk fat content in female finnraccoon and common foxes (%)

Stage of lactation	I $\bar{x}$	II $\bar{x}$	III $\bar{x}$
Finnraccoon	9.25 a	11.42 b	13.61 c
Silver fox	9.03	10.83 a	12.58 a

Mean marked with letters a,b (in rows) are significantly different (P≤0.05).

The intensive growth and development of pups is associated with their high demand for fat, in particular. On the basis of the obtained results, a significant influence of the lactation stage on the milk fat level was observed, especially in the case of the raccoon dogs (Tab. 3). In the milk of both species, a statistically significant increase in fat content in the II and III lactation stages was observed (P≤0.05). Both the milk of the female finnraccoon and common foxes from farm C had statistically significantly higher fat content (Tab. 4). This was probably due to a better balanced dietary intake and a more varied diet.

Table 4. Milk fat content in common fox and finnraccoon females depending on origin

Item	Farm W		Farm C	
	$\overline{x}$	SD	$\overline{x}$	SD
Common fox	9.69 a	2.04	13.06 b	0.79
Finnraccoon dog	10.50 a	3.02	13.61 b	1.69

The fatty acid profile is a composition of free fatty acids, which can be divided into saturated fatty acids, which contain an odd or even number of carbon atoms (SFAs), and unsaturated fatty acids, which contain even or odd number of carbon atoms (UFAs), including monounsaturated (MUFA) and polyunsaturated (PUFA) (Jensen et al., 1991).

The milk of both species was shown to contain 18 acids, including CLA (conjugated linoleic acid) – an acid with significant biological properties. 10 saturated fatty acids were identified. In the short-chain group, these were C4:0 butyric acid, C6:0 caproic acid and C8:0 caprylic acid. The following acids were found among the medium and long-chain saturated acids: C10:0 capric acid, C12:0 lauric acid, C14:0 myristic acid, C15:0 pentadecylic acid, C16:0 palmitic acid, C18:0 stearic acid, C20:0 arachidic acid. The following acids were found in the group of mono-unsaturated fatty acids (MUFA): C16:1n7 palmitoleic acid, C18:1 cis-oleic acid, C18:1 trans-oleic acid and C20:1n9 eicosenoic acid. Similarly, in the group of polyunsaturated fatty acid (PUFA), the following 4 acids were identified: C18:2n6 linoleic acid, CLA conjugated linoleic acid, C18:3n3 linolenic acid and C20:2n6 eicosadienoic acids.

A high similarity of the obtained contents of the individual fatty acids was found between the common fox and the raccoon dog (Fig. 1 a and 1 b). The total SFAs in the milk of female foxes and finnraccoon accounted for 32.01% and 31.64% of total fatty acids, respectively. UFAs in the milk of both females oscillated at a relatively even level of 65.36–65.58%, including 44.3% (common foxes) and 43.38 (finnraccoon) – the presence of the MUFA group acids. Oleic acid with the symbol of C18:1n9cis had the highest percentage share in the MUFA group in the milk of both species (Tab. 5).

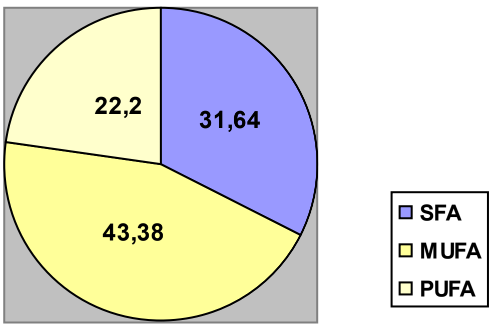

Fig. 1 a. Fatty acid profile of milk from female finnraccoon

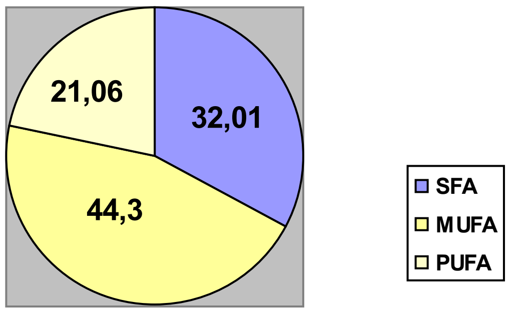

Fig. 1 b. Fatty acid profile of milk from female common foxes

Table 5. Fatty acid profile of milk from female Finnraccoon and common foxes

Species	Finnraccoon		Common fox	
Fatty acids (%)	$\overline{x}$	SD	$\overline{x}$	SD
Short-chain				
C4:0	0.05 a	0.02	0.06 a	0.02
C6:0	0.25 a	0.11	0.41 b	0.09
C8:0	0.01 a	0.00	0.01 a	0.01
Medium-chain				
C10:0	0.04 a	0.02	0.04 a	0.03
C12:0	0.52 a	0.36	0.44 b	0.24
C14:0	1.67 a	0.31	1.87 a	0.0
C15:0	0.13 a	0.04	0.16 b	0.06
C16:0	23.93 a	1.11	24.09 a	1.09
C16:1 n7	4.67 a	0.44	4.26 b	0.27
Long-chain				
C18:0	4.99 a	0.49	4.89 a	0.32
C18:1 n9 trans	0.20 a	0.10	0.35 b	0.19
C18:1 n9 cis	38.13 a	2.28	39.24 a	0.87
C18:2 n6	20.27 a	1.48	19.44 a	0.75
C18:2 CLA	0.08 a	0.09	0.05 b	0.02
C18:3 n3	1.60 a	0.35	1.38 a	0.24
C20:0	0.05 a	0.01	0.04 a	0.02
C20:1 n9	0.38 a	0.17	0.49 b	0.22
C20:2 n6	0.25 a.	0.02	0.21 b	0.03

The total of polyunsaturated fatty acids (PUFAs) in the analysed milk of female common foxes and raccoon dogs was 21.06 and 22.2%, respectively (Fig. 1). Among the fatty acids of this group, C18:2n6 linoleic acid was the most abundant in the milk of both females.

During the postnatal development, the nutritional needs of mammals change dynamically depending on the size of the litter, the age of the puppies and their condition. Fatty acids are one of the most important substances determining the proper development of the body during the postnatal period.

These substances are responsible for energy processes that take place in the cell and form the main building blocks of cellular membranes and are also precursors of substances that are important to metabolism, such as prostacyclin, prostaglandin, thromboxane and leukotriene. Fatty acids differ in their carbon chain length and the number of unsaturated bonds (Zaleska et al., 2010).

Our results (Tab. 6) indicate a clear relationship between the content of individual fatty acids in the milk of fox and raccoon dog females in the 2nd and 3rd lactation stage. It can be seen that the fatty acid profile changed significantly as the lactation continued ($P \leq 0.05$). A marked increase was observed in the case of unsaturated oleic and linoleic acids, whereas in the case of saturated and unsaturated acids, including CLA, a decrease in the content was observed.

Table 6. Fatty acid profile of milk from female finnraccoon and common foxes depending on stage of lactation

Stage of lactation	II		III	
Fatty acids (%)	finnraccoon	fox	finnraccoon	fox
C4:0	0.04 a	0.06 a	0.05 a	0.05 b
C6:0	0.30 b	0.46 a	0.22 b	0.39 a
C8:0	0.01 b	0.02 a	0.01 b	0.01 a
C10:0	0.04 ab	0.04 a	0.04 b	0.05 a
C12:0	0.86 a	0.48 a	0.24 c	0.42 a
C14:0	1.93 b	1.73 a	1.46 c	1.92 a
C15:0	0.13 a	0.17 a	0.12 a	0.16 a
C16:0	**25.03 a**	**24.77 a**	**23.00 b**	**23.83 a**
C16:1 n7	4.42 a	3.98 a	4.88 a	4.37 b
C18:0	5.34 a	4.74 a	4.70 b	4.95 a
C18:1 n9 trans	0.23 ab	0.41 a	0.17 b	0.33 a
C18:1 n9 cis	**36.59 a**	**39.17 a**	**39.42 b**	**39.27 a**
C18:2 n6	**18.82 a**	**19.41 a**	**21.48 b**	**19.46 a**
C18:2 CLA	0.13 b	0.04 a	0.03 a	0.05 a
C18:3 n3	1.32 a	1.23 a	1.84 a	1.44 a
C20:0	0.04 a	0.03 a	0.05 b	0.04 a
C20:1 n9	0.52 b	0.40 a	0.25 c	0.52 b
C20:2 n6	0.27 b	0.23 a	0.24 b	0.18 b

Means marked with letters a,b,c (in rows) are significantly different (P≤0.05).

Photo 2. Young finnraccoons on farm W

During the first three weeks of life of young foxes and raccoon dogs, the female's milk is their main food and the rate of growth and development of young foxes and raccoon dogs during the sucking period is very high. According to Jarosz (1993), pups increase their mass almost threefold in the first month of life. The unique property of the milk fat of foxes and raccoon dogs is the presence of conjugated linoleic acid (CLA), which has many specific functional properties and health benefits. The presence of CLA in animal tissues, particularly in ruminants, is associated with the activity of bacteria (including Butyrivibrio fibrisolvens) in masseter which take part in the process of biohydrogenation of unsaturated fatty acids. CLA is an intermediate product of incomplete hydrogenation of linoleic acid (Paszczuk et al., 2005). According to Janczy (2012), lamb is characterised by the highest content of CLA (4.3–19.0 mg/g of fat). Beef contains a slightly smaller amount of this acid (1.2–10.0 mg/g of fat). The concentration of CLA in pork, chicken and horse meat is usually lower than 1 mg/g of fat but these by-products of animal origin are the dietary basis for carnivorous fur farming animals.

Conclusions

1. The milk obtained from common fox and raccoon dog females was characterised by a high fat content.
2. The lactation stage had a significant impact on the basic chemical composition of the obtained milk. As the lactation continued, a successive increase in the fat content was observed, which was confirmed statistically.
3. The fatty fractions in the milk of both species are characterised by the presence of both short-, medium- and long-chain saturated fatty acids (SFAs) as well as monounsaturated (MUFAs) and polyunsaturated fatty acids (PUFAs).
4. When determining the fatty acid profile of the tested milk of females of both species, the presence of 18 acids was found.
5. The content of most fatty acids does not exceed 1%, except for palmitic, cis-oleic and linoleic acids, which account for about 20%.

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FAT CONTENT AND FATTY ACID PROFILE OF MILK FROM FARMED CANIDS

Summary

The aim of the study was to determine the fat content and fatty acid composition of milk from farmed female finnraccoons and common foxes. Milk samples collected from 20 lactating females of both species were studied. The animals came from two farms located in the Świętokrzyskie and Podkarpackie voivodeships.

The analysis showed a high milk fat content of 12.46% in finnraccoons, and 10.21% in common foxes. The milk fat content in both species varied according to the origin of females and stage of lactation. The analysed milk samples were found to contain eighteen fatty acids. Ten fatty acids were identified. Among saturated fatty acids, there were 4 monounsaturated (MUFA) and 4 polyunsaturated fatty acids (PUFA), including conjugated linoleic acid (CLA), which is important due to its properties. Most of the fatty acids occurred in small quantities (below 1%). Milk from both species had the highest content of the fatty acids palmitic C16:0, cis-oleic C18:1 n9 cis and linoleic C18:2n6cis.

Key words: milk, finnraccoons, common fox, fat, fatty acids profile

Phot. O. Szeleszczuk