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Effects of Grass and Legume Fed on the Fatty Acid Composition of Lipids in Cow's Milk (X)

Effects of Drying and Storage on the Fatty Acid Composition of Pasture Grasses

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Summary

The fatty acid composition of lipids in hay was determined by gas-liquid chromatography and these values were compared with the fatty acid composition of fresh pasture grass.

The same fatty acids constituted the major part of the lipids in hay and in fresh forages. But these fatty acid compositions were influenced by the methods of hay making and storage.

When the forages were dried as rapidly as possible at a high temperature and were stored for only a short period, the lipids of the hay had nearly the same fatty acid composition as fresh forages after cutting. In the case of lipids in hay dried at a low temperature and stored for a long time, the linolenic acid and linoleic acid decreased and the palmitic acid increased.

The close relation between linolenic acid and palmitic acid was shown by the correlation coefficient of $r=-0.89$.

It is well known that the texture of butter made of the milk of cows on winter feeds is harder than the butter of those on summer forages. There has been no paper which illustrated clearly this fact from the view-point of fatty acid composition. On the supposition that fatty acid composition may be changeable, some countermeasure must be taken for the changes of fatty acid composition. Therefore it may be seen that the influence of drying and storage on the fatty acid composition of lipids in orchard grass, ladino clover and others, is important for nutritive physiology of cattles and for the properties of the milk products.

Collins & Shorland have studied the changes of the total amounts of fatty acids and phospholipids in grass with drying and storage periods of relatively

short duration (1). The effect of temperature of storage on the content of fat extracted from hay was studied by Couchman (2). It was found by Thafvelin & Oksanen that during the drying and storage of hay the percentage of linolenic acid decreased in the total fatty acids (3).

In the previous papers it has been reported that the fatty acid composition of lipids in grasses and legumes was affected by many factors (4–7) and that in the preservation by ensilage, the composition of lipids also changed notably from that of raw fresh forage (8). Orchard grass (*Dactylis glomerata*), ladino clover (*Trifolium repens latum*) and others have been chosen for the present experiment because they are cultivated very widely. The changes during drying and storage have been studied comparing the fatty acid composition of lipids in hay with that in fresh pasture grasses.

Experimental Procedure

Exp. 1

In this experiment the grassland was seeded with orchard grass and ladino clover. The experimental places, the fertilizers, the cutting times and the other managements of the grassland were the same as those described in the previous experiment (6).

The freshly cut grasses were dried to the mean moisture of 13.20 percent in a barn made of vinyl plate at 20 to 45°C for about seven days and placed in shallow bags for storage at room temperature for a period of from 600 to 730 days.

Exp. 2

The experimental forages are Kentucky blue grass (*Poa pratensis*), perennial ryegrass (*Lolium perenne*), red top (*Agrostis*) and meadow fescue (*Festuca elatior*). Each grass was cultivated free from other genus in an experimental field of the Miyagi Prefectural Agricultural Experiment Station. The grassland was well fertilized and managed. After the first cutting of the second year, these freshly cut grasses were dried in an oven at 60°C for two days. The dried grasses were wrapped in paper and cured for a period of forty days at room temperature, and then subjected to the chemical analysis. The average humidity of the hay was 10.30 percent.

Sampling and Methods of Analysis

The dried forages (10 g) were weighed as samples of Exp. 1 and 2 after storage. The analytical methods used were the same as those reported previously (9).

Results

Exp. 1

The fatty acid compositions of the lipids in the hay of orchard grass and ladino clover produced during the experimental period in each season are shown in

TABLE 1. *The Average Fatty Acid Composition of Lipids in the Hays of Orchard Grass and in Ladino Clover Cultivated in Three Experimental Fields.*

Forage	Orchard grass			Ladino clover		
Season	Spr.	Sum.	Aut.	Spr.	Sum.	Aut.
Saturated fatty acid						
C_8	2.91	3.45	2.13	2.20	3.40	1.92
C_{10}	0.52	0.97	1.49	0.40	1.39	0.76
C_{13}	1.47	3.34	2.70	1.68	3.76	1.91
C_{14}	1.41	1.67	1.76	0.52	0.94	0.67
C_{15}	0.48	0.58	0.78	0.79	1.07	0.75
iC_{16}	1.63	5.38	3.63	2.37	5.29	3.55
C_{16}	35.31	23.33	22.77	31.93	34.77	21.23
C_{17}	1.50	1.15	1.13	1.69	1.00	0.76
iC_{18}	0.34	0.73	0.56	0.32	0.37	0.42
C_{18}	1.11	1.20	0.39	0.99	1.03	0.39
Total	46.70	41.79	37.34	42.89	53.03	32.36
Unsaturated fatty acid						
$C_{10}^{1=}$	1.42	2.34	2.00	1.59	0.89	0.54
Unknown	12.69	24.50	26.53	15.82	21.25	23.24
$C_{16}^{1=}$	1.91	1.30	2.23	1.77	2.51	1.31
$C_{18}^{1=}$	2.19	2.71	1.67	3.05	3.86	3.59
$C_{18}^{2=}$	14.48	14.67	9.38	13.58	12.51	16.19
$C_{18}^{3=}$	20.60	12.69	20.86	21.29	5.94	22.76
Total	53.29	58.21	62.66	57.11	46.97	67.64

Table 1, giving the average values of the results gained from experiments in three places.

The fatty acid composition of lipids in the hay was fairly different among the hays obtained in the three seasons. In each hay, the levels of C_{16}, $C_{18}^{2=}$, $C_{18}^{3=}$ and the unknown unsaturated fatty acids were much higher than those of the other fatty acids. The two unknown fatty acids and $C_{18}^{3=}$ were found to constitute about 80 percent of the total unsaturated fatty acids in every group. The levels of these fatty acids showed considerable variation. In the spring and autumn samples, linolenic acids predominated, but the oleic and linoleic acids were inferior.

Comparison of the fatty acid compositions of lipids in hays with those of the lipids of fresh forages after cutting are shown in Fig. 1. The Linolenic acid content of the hay lipids decreased remarkably from the value of fresh forage to a lesser extent. The Linoleic acid also decreased, but the palmitic acid and the unknown fatty acid increased.

Exp. 2

The average values for fatty acid compositions of lipids in fresh forages and hays of four different genera cultivated by single seeding are shown in Table 2.

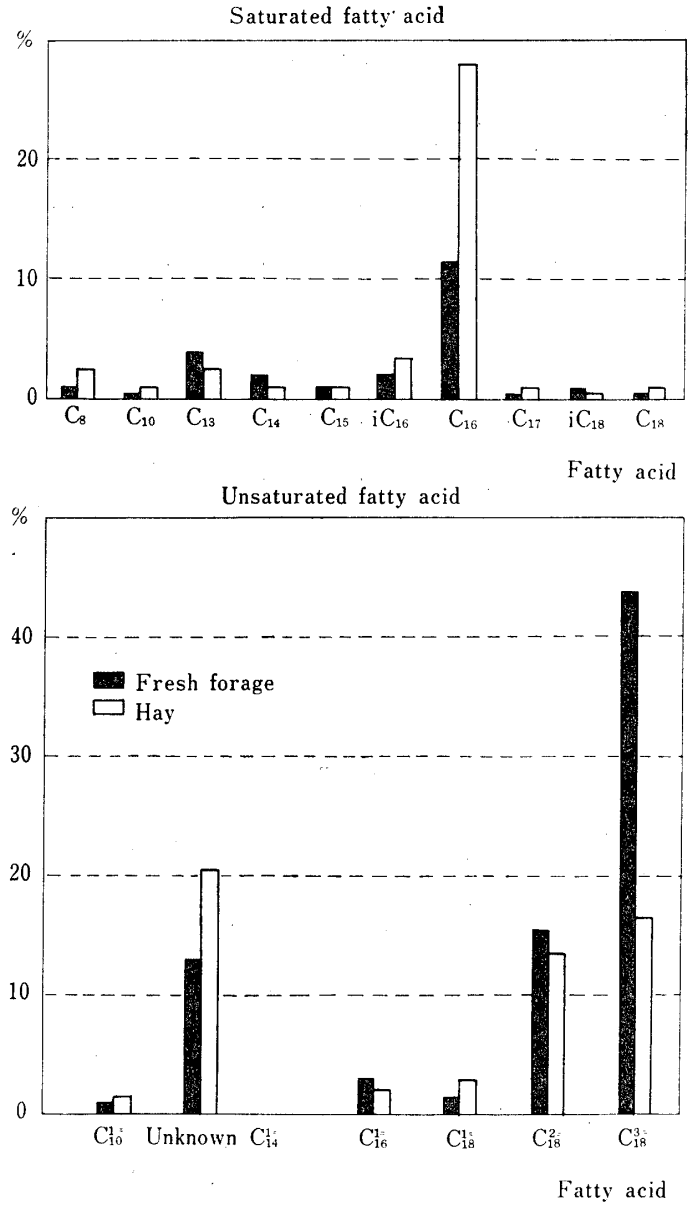

FIG. 1. The mean of the fatty acids of lipids in fresh forage and in hay at Exp. 1.

Fatty acid compositions of lipids in the hays were not so different from those in the fresh grasses. With rapid dehydration of fresh grasses in a drying oven, the linolenic acid as major fatty acid, linoleic acid and plamitic acid percentages did not change. The unknown fatty acid increased to some extent. Accordingly the total saturated fatty acids and unsaturated fatty acids of the hay were almost the same in content as the fresh grasses.

Discussion

A Comparison of the results of Exp. 1 and Exp. 2 are summarized in Table 3. From the results of these experiments, when orchard grass and ladino

TABLE 2. *The Average Fatty Acid Compositions of Lipids in Fresh Forages and in the Hay of Four Different Genera*[a] *Cultivated by Single Seeding*

Saturated fatty acid %

Sample	C_8	C_{10}	C_{13}	C_{14}	C_{15}	$_iC_{16}$	C_{16}	$_iC_{18}$	C_{18}	Total
Fresh forage	1.08	0.19	0.41	0.38	0.06	0.54	15.01	0.16	0.16	17.99
Hay	0.53	0.18	0.08	0.70	0.15	0.74	13.87	0.03	0.87	17.85

Unsaturated fatty acid %

Sample	$C_{10}^{1=}$	Unknown	$C_{14}^{1=}$	C_{16} =	$C_{18}^{1=}$	$C_{18}^{2=}$	$C_{18}^{3=}$	Total
Fresh forage	0.21	7.85	0.36	1.67	1.37	13.98	56.59	82.01
Hay	0.24	10.29	1.08	1.50	0.90	11.89	56.26	72.15

a) Four different genera: Kentucky blue grass, perennial ryegrass, red top and meadow fescue.

TABLE 3. *The Comparison of the Results Obtained from Exp. 1 and Exp. 2*

Item	Exp. 1		Exp. 2	
	Orchard grass, Ladino clover		Perennial ryegrass, Red top, Meadow fescue, Kentucky blue grass	
	Fresh grass	Hay	Fresh grass	Hay
Moisture	83.3 %	13.20%	84.6%	10.30%
Crude fat	0.58%	3.01%	0.70%	4.08%
Drying method		Barn made of vinyl plate		Drying oven
Storage period		600-700days		40days
Color	Green	Faded color	Green	Green
Saturated fatty acid	23.12%	42.34%	17.98%	17.85%
Unsaturated fatty acid	76.59%	57.65%	82.02%	82.15%
Unsaturated index	3.34%	1.36%	4.56%	4.58%
Major fatty acid				
Linolenic acid	43.70%	17.47%	56.59%	56.26%
Linoleic acid	15.51%	13.47%	13.98%	11.26%
Palmitic acid	11.62%	28.22%	15.01%	13.87%

clover are dried as rapidly as possible at a high temperature and stored for only a short period, the unsaturated fatty acids are stable and the change of fatty acid is not so evident.

When the forages were dried at a low temperature and stored for a long time, the linolenic acid decreased remarkably. Antagonistically each percent of unknown, palmitic, and oleic acids increased. The results of these studies corresponded generally with the results of Czerkawski (10). Accordingly, it is supposed that the possibility for change of fatty acid compositions is geater in the

storage process than in the drying process which is common now.

Kanamori et al. reported that the lipids of freeze-dried chicken were oxidated during storage (11). The oxidation of the lipids in vegetables would be also promoted when the moisture content decreased greatly. Lipoxidase is contained in legumes but is not in grasses (12). Therefore it is considered that the promotion of enzymatic oxidation may not be recognized during the drying process of these experiments and the decline of the fatty acid may be caused principally by chemical oxidation. In order to maintain the same fatty acid composition as in the original materials the storage condition would be important.

The close relation between linolenic acid and palmitic acid was shown by the correlation coefficient of r=–0.89. The contents of linoleic and the unknown fatty acids showed less variation than the linolenic acid.

In the experiments of Hardy M. Edwards (13) and Y. Watanabe (14), it was reported that the linolenic acid in hay showed 38 to 59 percent and the palmitic acid 16 to 32 percent increases. This fact illustrated that the fatty acid composition of lipids in hay is unstable.

From the above mentioned considerations, it has been confirmed that these variations of the fatty acid composition in hays were influenced by the methods of hay making and storage, and by the length of storage. The great difference in the fatty acid composition of the lipids in hay, when compared with fresh grass, was its worse quality.

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