EFFECTS OF FRUCTO-OLIGOSACCHARIDES ON MILK-YIELD AND MILK-COMPONENTS OF DAIRY COWS

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Summary

Fructo-oligosaccharides are found in many plants, such as onion, burdock and wheat. They are not well hydrolyzed by digestive enzymes in animals, but are peculiarly assimilated by *Bifidobacterium* and some useful bacteria. In our previous experiment (Kobayashi et al., 1987), it was suggested that they were effective in decreasing energy loss in the metabolism of dairy calves. In the present study, the effects of fructo-oligosaccharides on body weight, milk-yield and milk-components (fat, protein and solids-not-fat) were investigated in dairy cows. Lactating cows were fed a standard diet containing fruct-oligo saccharides at 18.70g, 9.35g and 0.0g (control) per 100kg body weight, day for three weeks. Neither treatments significantly affected any of the parameters examined. The fructo-oligosaccharides were assumed to be hydrolyzed by rumen microorganisms and hardly to affect the bacterium florae in the intestines of the lactating cows.

(Key Words: Fructo-Oligosaccharides, Milk-Yield, Milk-Component, Dairy Cow)

Introduction

Fructo-oligosaccharides (FO-sugar) are 1^F-(1-β-fractofranosyl)$_{n-1}$ sucrose, that is, 1-kestose (n=2, GF_2), nystose (n=3, GF_3), 1^F-β-fructofuranosyl nystose (n=4, GF_4), and so on. FO-sugar is manufactured from sucrose by using a fractosyl-transferase of *Aspergillus* or *Aureobasidium* (Hidaka, 1982). In fact, FO-sugar is obtained as Neo-sugar which is a mixture of fructose, sucrose, GF_2, GF_3, GF_4, etc, and the proportion of FO-sugar is about 55%.

Neo-sugar is a colorless, transparent liquid, with 60-80% of the sweetness of sucrose, and a relatively high heat-tolerance in the neutral zone (Fuwa, 1982; Hidaka, 1982). FO-sugar is actually found in many kinds of plants, such as onion, burdock, asparagas root, tubers of Jerusalem artichoke and wheat (Fuwa, 1982).

FO-sugar is only partially hydrolyzed by enzymes in the small intestines of rats (Mudock et al., 1980) or by human saliva enzyme (Hidaka et al., 1984). It decreased the serum levels of cholesterol, triglyceride and phospholipid in rats (Oku et al., 1982). It can be utilized as a low-caloric sugar with no absorption (Hidaka et al., 1984). Mitsuoka et al.(1982) found that FO-sugar increased *Bifidobacterium* in the human rectum and suppressed the multiplication of noxious bacteria. In the domain of medical services, FO-sugar was applied to diabetes mellitus successfully (Yamashita, 1984; Sano, 1986).

In animal husbandry, FO-sugar has been administered to piglets and broilers. Fukuyasu et al. (1986) reported that FO-sugar prevented the occurrence of diarrhea, decreased putrefactive substances in feces and increased body weight gains on piglets during the four weeks after weaning. Nakamura (1986) also reported the effectiveness to bacterium flora, which was considered to cause diarrhea, in intestines on sows. Mimura (1986) reported the decrease of Enterobacteriaceae in caecum on chickens.

In ruminants, the rations fed are attacked by bacteria and protozoa in the rumen, and so the digestion of FO-sugar will be different from non-ruminants. Kobayashi et al. (1987) gave FO-sugar to dairy calves of 11-43 days of age for 11 weeks and found that *Lactobacillus* and *Streptococcus* increased and *Clostridium perfringens* decreased,

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but that pH-value and solidity of feces were improved little by FO-sugar. Also they reported an increase in the body weight of calves fed FO-sugar, especially older calves. It is assumed that the effects of FO-sugar on dairy calves were caused by the predominant position of useful bacterium-flora in the intestines and the subsequent suppression of energy loss in the metabolism, particularly as because the rumen is not well developed and the activity of rumen microorganisms is not high in calves (Elliot et al., 1980; Johnson et al., 1982; Kameoka, 1965; Ueda et al., 1982).

In this study, the effects of FO-sugar on body weight, milk-yield and milk composition were investigated in order to ascertain the possibility of FO-sugar utilization by dairy cows.

Materials and Methods

Twelve dairy cows of 2.6 to 4.7 years and of one to three parturitions were divided into three groups according to age and parturition. Groups A, B and C were given the standard ration (table 1) containing FO-sugar at 18.70g, 9.35g and 0.0g per 100kg body weight, respectively. In each herd, two cows were pregnant (6 or 7 months after the former parturition) and the other two cows were uncertain in pregnancy (4 or 5 months after the former parturition) at the beginning of the experiment.

The FO-sugar used in this study was prepared from sucrose with a fructosyl-transferase of *Aspergillus niger* origin. The composition of FO-sugar was GF_2, 13.2%; GF_3, 14.3%; GF_4, 2.8%; glucose or fructose 19.2%; and sucrose, 50.5%.

Individual cows records of body weight, milk-yield (average for 3 days before and after), milk fat, milk protein, and total milk solid were taken every week. The milk components were analyzed by using a Milko-scan 203 (Foss Electric Co., Denmark). The values measured were analyzed statistically using analysis of variance.

TABLE 1. RATION COMPOSITION

Feed	Quantity[1]
Grass silage[2] (DM 39%)	19.0
Wheat bran	1.8
Rolled corn	1.6
Rolled barley	2.6
Cotten seed	1.2
Soybean meal	0.8
Beet pulp	2.0
Alfalfa pellet	1.6
By-products from beer brewing	1.6
Fish meal	0.12
Vitamin premix	0.04
Mineral mix	0.14
Table salt	0.06

[1]kg per head per day.
[2]Composed of Italian ryegrass, orchard grass, reed canary grass, timothy, red clover.

Results and Discussion

Body weight

During the experimental period of FO-sugar feeding, average body weights increased from 591 ± 61kg to 605 ± 62kg in Group A, from 600 ± 52kg to 616 ± 46kg in Group B and from 577 ± 58kg to 585 ± 46kg in Group C (control). The difference in body weight gain between the treatments was not significant (table 2). Cows of first parturition gained more weight gains than those of second and third parturition (significant

TABLE 2. ANALYSIS OF VARIANCE OF BODY WEIGHT GAINS[1]

Factor	Sum of squares	Degree of freedom	Unbiased estimate of population	F-value
Calving number[2]	154	1	154	1.74[a]
Treatment	60	2	30	0.34
Error	708	8	89	
Total	922	11		

[1]Body weight change during the three weeks of FO-sugar feeding was analysed.
[2]One group was composed of cows of the first parturition, and the other of the second and third parturition.
[a]Significant at p = 0.10.

at p = 0.10).

Milk-yield

Throughout the experimental period, milk-yields in all groups decreased a little, especially toward the day three weeks after the beginning of the experiment (figure 1). This gradual decline could have been caused by a higher environmental temperatures on those days or a change in quality of silage which was stored in a big steel silo, because the decline was similar for all groups.

Ratios of milk-yield at the end of FO-sugar feeding in comparison with that at the beginning of FO-sugar feeding were individually calculated, and the difference between the treatments was analysed (table 3). The differences between the treatments and also between months after parturition were very small. In Group A, the dose of FO-sugar was equivalent to 1.2% of feed dry matter per day, head If this FO-sugar is hydrolyzed in rumen, it would be utilized as an energy source in metabolism. The energy equivalent of this FO-sugar is however too low to affect milk production.

From the negative effect of FO-sugar on milk yield, it is assumed that FO-sugar didn't significantly affect the bacterium flora in the small intestine and that it may have been hydrolyzed in

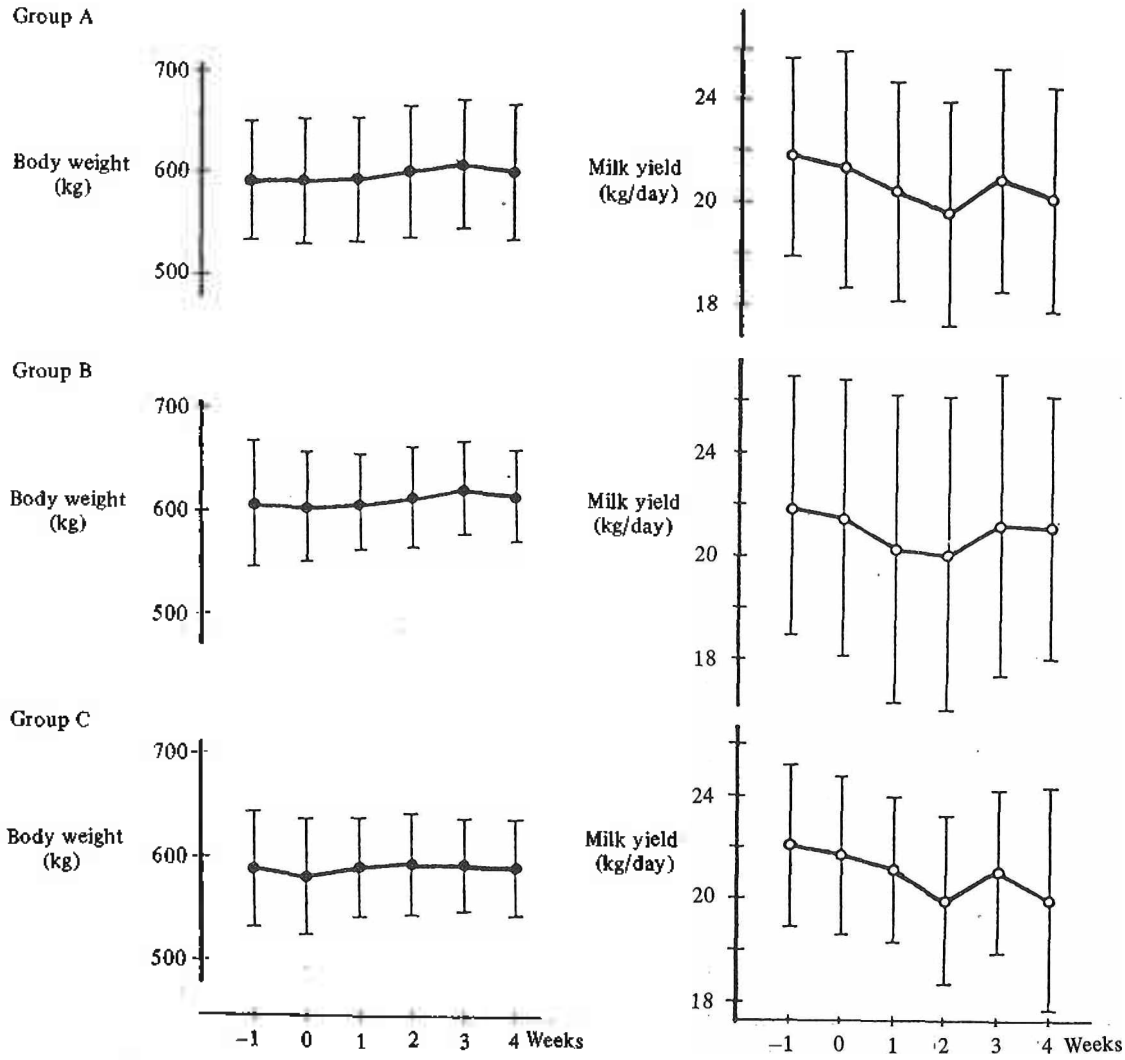

Figure 1. Body weight and milk-yield in each group (Mean ± SD).

TABLE 3. ANALYSIS OF VARIANCE OF MILK-YIELDS[1]

Factor	Sum of squares	Degree of freedom	Unbiased estimate of population	F-value
Months after calving[2]	1724	3	575	0.374
Treatment	479	2	240	0.156
Error	9222	6	1537	
Total	11425	11		

[1]Changes in milk-yields were calculated as ratios of milk-yield at the end of FO-sugar feeding to that at the beginning of FO-sugar feeding.
[2]In each treatment, cows were included whose former parturitions were 4, 5, 7 or 8 months before.

rumen.

Milk-fat

Milk-fat content in each group is shown in figure 2. During the FO-sugar feeding, it changed from 3.90 ± 0.66% to 3.51 ± 0.42% in Group A, 3.51 ± 0.18% to 3.48 ± 0.23% in Group B, and 3.59 ± 0.33% to 3.41 ± 0.59% in Group C. The changes during the experimental period differed a little between treatments, but lower levels of milk-fat content were common four weeks after the beginning of the experiment and higher levels were also common at the end of the period in all groups. Temperature changes over this time (from the highest temperature in a day 29-30°C to the same 26-27°C) could have affected the milk-fat contents of cows.

Milk-fat yields were calculated individually by multiplying milk-fat content and milk-yield. Changes in each group were computed as ratio of milk-fat yield at the end of FO-sugar feeding to that at the beginning of FO-sugar feeding. The

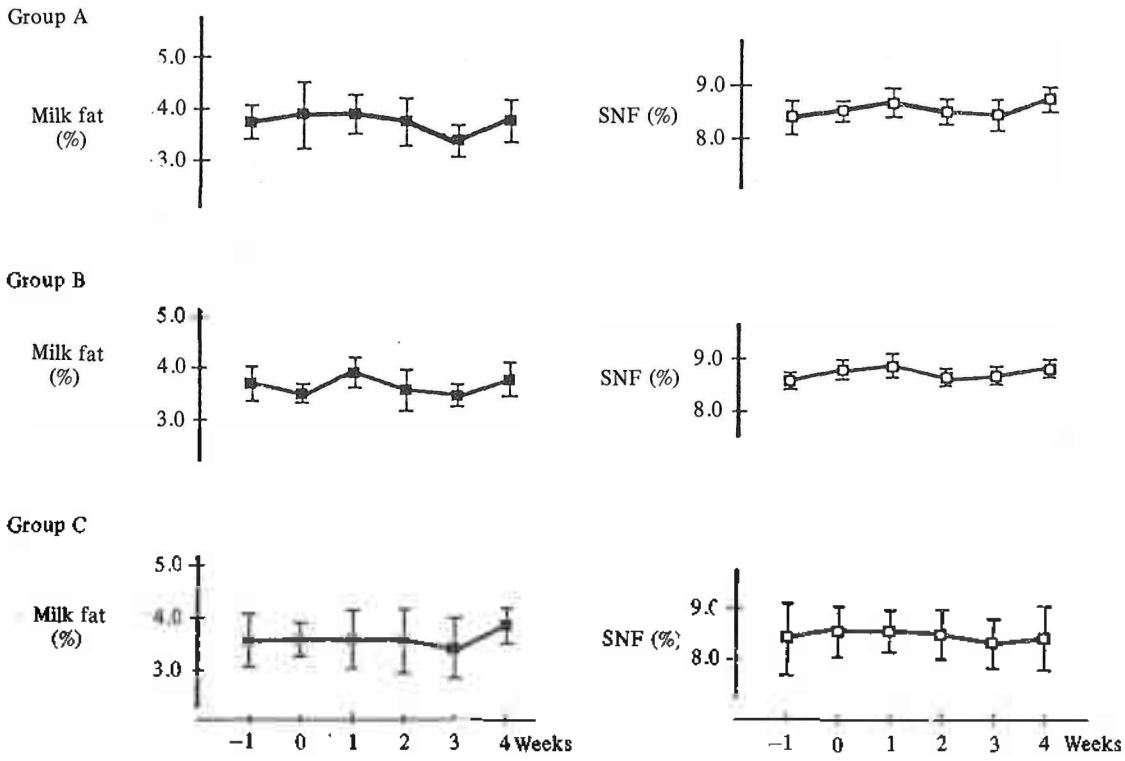

Figure 2. Contents of milk-fat and solids-not-fat in each group (Mean ± SD).

difference between the treatments was not significant, but the difference between months after parturition, that is, milk-fat yield of cows 4 months after parturition was significantly lower than that on other cows. This suggests a sensitivity of cows later in lactation.

Solids-not-fat

Solids-not-fat (SNF) tended to be parallel to milk-fat content in all groups (figure 2). During the FO-sugar feeding, they changed from 8.58 ± 0.22% to 8.46 ± 0.28% in Group A, 8.78 ± 0.16% to 8.67 ± 0.16% in Group B, and 8.58 ± 0.53% to 8.37 ± 0.51% in Group C. Solids-not-fat yields were calculated individually by multiplying solids-not-fat and milk yield, and the changes were shown as ratios of values at the end of FO-sugar feeding to those at the beginning of FO-sugar feeding. The difference of the changes between treatments was not significant, and that between months after calving was also very small.

Milk-protein

Milk-protein content was relatively the same level throughout the experimental period in all groups. They changed from 3.10 ± 0.13% to 2.98 ± 0.12% in Group A, 3.15 ± 0.08% to 3.03 ± 0.14% in Group B, and 3.00 ± 0.20% to 2.83 ± 0.20% in Group C during the three week of FO-sugar feeding. The difference of changes during the period between treatment was very small.

For all factors measured in the experiment, the differences between the treatments were very small, and environmental factors may have had a greater effects on them. FO-sugar was given at two doses, but the change of milk-fat yield was a little higher in the lower feeding group (group B) than in higher feeding group (group A). Therefore higher doses of FO-sugar than a dose 0.34g/kg b.w./day as Neo-sugar given to Group A are unlikely to have an affect on milk-yield or milk-components.

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