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Research Article

Effect of Feeding Strategies on Milk Production of Holstein Dairy Cows Managed by Small-Farmers Alpine Grassland in Korea

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ABSTRACT

The main objective of this experiment was to investigate effects of two different feeding systems on body weight, milk yield, milk composition, and mineral and fatty acids content of Holstein dairy cows' milk. Sixteen of 25 months-old Holstein dairy cows were assigned to two groups (n=8) to study effects of the feeding system for 150 days. Two feeding systems were compared for five months; Group 1 was housed indoors and mainly fed a concentrate diet, Group 2 was maintained outdoors for five-seven hours/day on various kinds grass in a pasture. The experiment was conducted June-October 2017. Results revealed the indoor-fed cows had higher body weight, that was significant compared with the outdoor-based feeding system of Holstein dairy cows ($p<0.05$). Indoor-raised milking cows had higher milk yield (32.45 kg) as compared with pasture-raised milk yield (26.44 kg). Cows fed indoors significantly increased milk yield, total protein content, lactose, citric acid level, and lowered level of total solid and free fatty acids relative to the pasture-fed milking cows ($p>0.05$). There were higher levels of mineral content and fatty acid content in the milk of indoor-fed dairy cows than the pasture-raised dairy cows ($p>0.05$). Our study results demonstrated the potential benefits of the indoor feeding system for increased body weight, milk yield, mineral and fatty acids content summer through autumn when low pasture growth rates and quality may otherwise limit production.

(**Key words** : Holstein dairy cow, Feeding system, Average daily gain, Milk yield, Minerals, Fatty acids)

Ⅰ. INTRODUCTION

Consumption of milk has been increasing as per capita in Korea, is estimated to increase from 64.2 kg to 76.4 kg/ year in the year 2002 and 2016 respectively. However, the milk producing dairy cow in Korea is still low (Korea Dairy Committee, 2017). Despite, feeding strategy to increase milk production via protein supplementation has been broadly studied. Therefore dairy cows producer has more attention on improving favourable competence and profitability based on growth characters through feeding system were focused on increasing milk production and their compositions. These growth and milk characters have been selected based on their outcome without estimating their input cost to achieve this production level. However, the cost of production increases, total input and input cost also need to be considered for selecting production manners. This is the most important factor because of the financial cost is associated with feed inputs, which could influence the profitability of cow-calf operation (Miller et al., 2001). It is becoming more important for livestock producers. Pasture-based dairy farming in Korea is characterised by high production costs and low pasture utilisation. However, this reliance on pasture often means that production per cow is low by world standards and milk production on Korean dairy farms falls sharply during the summer-autumn season due the accessibility and excellence of ryegrass pastures (Hur et al., 1999). Maintenance of high pasture quality will assist in achieving this, but even then it is likely that the inherent characteristics of pasture as a feed, such as high fibre content, will limit dry matter intake (DMI)

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to levels that constrain milk yields to 25 - 30 L/d. The objective of this study was to evaluate the effects of 2 widely practiced feeding systems namely indoor and pasture on body weight, milk yield and mineral content of Holstein milking cows.

The livestock requires dietary energy is essential for the maintenance of reproduction and milk production. To support the high energy and nutrient demands of dairy cattle is needed to emphasize on their diets. Feed is the most important factor for the livestock production, about 60-70% of production expenditures should be fixed according to the previous literature (Strauch and Stockton, 2013). However, feeding diets high in readily fermentable carbohydrates increases the odds of developing sub-acute ruminal acidosis and decreases the long-term productive performance of dairy cows (Zebeli et al., 2008). Also, numerous of studies have recently demonstrated that feeding of highly degradable carbohydrates, results in disorders such as acidosis, fatty liver, laminitis, liver abscesses, displaced abomasum, and bloat in cattle (Ametaj et al., 2005). The relationship between the feeding system and growth characteristics, milk yield, milk compositions and milk mineral content in Holstein milking cows are not yet studied. Therefore, the objective of this study was to evaluate the effects of two widely practiced feeding systems namely indoor and pasture on body weight, milk yield and mineral content of Holstein milking cows.

Ⅱ. MATERIALS AND METHODS

1. Experimental site and feeding system management

Sixteen 25 months old 1st parityof Holstein dairy cows with an initial body weight of 571.61 ± 35.30 kg (indoor) and 578.10 ± 39.20 kg (pasture) were assigned into 2 groups (n=8) at Medow ranch located in Gurye-gun, Jeonnanm, Republic of Korea. The experiment was conducted from June to October 2017. The animals used in this study were cared for and maintained according to the standard guidelines approved by the Animal Testing Ethics Committee of the National Institute of Animal Science, RDA, Republic of Korea. Two feeding system was compared over a five months; group 1 was housed indoors and mainly fed a concentrate diet (Alfalfa and Timothy), group 2 was maintained at outdoors for 5-7 h/d on a various kind grass (Tall fescue-10%, Orchard grass-10%, Kentucky bluegrass-45%, White clover-5% and wild grass-30%) in pasture. We evaluate the effects of feeding systems on body weight, milk yield and milk compositions, milk mineral content of Holstein milking cows. The experimental animals supplied diet, on a dry matter basis as presented in Table 1.

2. Analysis of body weight, milk composition, milk mineral content of Holstein dairy cows

During the study period, all the cows were individually weighed to measure the average body weight (kg). Milk samples were collected weekly once from the later lactation periods (200 to 305 days) of the dairy cows for the analysis of chemical composition and mineral content by a LactoScope (MK2; Delta Instruments, the Netherlands).

3. Statistical analysis

All the experiments were analyzed with using three replicates. Statistical analyses were performed using the SAS

Table 1 Chemical composition of basal diet for Holstein dairy cows (% DM)

Item (%)	Concentrate	TMR	Roughage (Timothy)	Grass (mixed)
Moisture content	11.54	13.37	13.50	71.88
Crude protein	16.45	14.83	9.54	11.65
Crude fat	5.35	7.09	4.71	5.12
Crude fiber	8.06	21.85	40.89	30.10
Crude ash	6.58	8.10	7.19	8.25
Calcium	1.26	0.61	0.19	0.24
Phosphorous	0.51	0.34	0.25	0.26
NDF		28.85	68.95	68.83
ADF		10.26	39.94	39.38

System for Windows (release 9.2; SAS Institute, Cary, NC, USA). Data were analyzed using means and the standard error of mean on the basis by t- test (SAS Institute, 2007). Significant differences were declared at p <0.05 level.

Ⅲ. RESULTS AND DISCUSSION

The principal aim of the present study was to investigate the performance, milk yield, milk composition, mineral and fatty acids content of indoor and pasture based feeding with a limited summer to autumn period. This is the first study to investigate differences in productivity and efficiency on Holstein dairy cows in two different feeding systems under equal conditions. The current market situation, with its risk of rising feed prices due to greater demand (FAO 2013), agricultural reforms, drought and ecological considerations may indicate that self-sufficient farming using local resources (e.g. pasture) on smallholder farms will become more important in the future.

The results of the current study demonstrated that indoor and pasture-feeding system had a significant effect on average body weight and milk yield of Holstein cows throughout the experimental period. The indoor-fed dairy cows showed the greater body when compared with outdoor-based feeding system of Holstein dairy cows (Table 2). A higher energy requirement in the pasture-based feeding cows due to the physical activity on the pasture might have resulted in a lower coefficient of milk efficiency (Kaufmann et al. 2011). The feed conversion efficiency in the pasture-based feeding cows was slightly lower than the results of Schori & Munger (2010).

The cows raised the indoor-concentrate based feeding system produced milk with significantly lower milk fat and greater milk protein, milk lactose, milk citric acid, milk total solids and milk free fatty acid production than that of outdoor-based feeding system are shown in Table 3. The milk mineral content of calcium, phosphorus, potassium, magnesium, zinc and iron from cows on the indoor feeding system was significant than that of pasture-based feeding system (Table 4). Our study results supported by Reynolds (2006) study which reported that grains such as maize used in TMR diets could provide a high proportion of starch for digestion in the small intestine leading to an increase in milk yield and a decrease in milk fat concentration. The pasture-based feeding cows did not show this increase in milk performance in the study period because of may be poor adaptation process of metabolism and energy availability.

The milk fatty acids content of dairy cows raised indoor feeding system was significantly higher than that of pasture-based feeding system (Table 5). The suboptimal feed and energy availability in the continuous pasture-based feeding system,

Table 2 Growth characteristics of Holstein dairy cows in indoor and pasture-based feeding systems

	Indoor	Pasture
No. of Animal (herd)	8	8
Initial age (month)	25	25
Final age (month)	30	30
Feeding period (days)	150	150
*Body weight, kg/herd		
Initial (kg)	571.6 ± 35.3	578.1 ± 39.2
Final (kg)	610 ± 20.0	600 ± 60.05
Gain (kg)	38.4 ± 0.21	21.9 ± 0.06
Milk Yields (kg)	32.45	26.44
Crude fat (%)	4.00	4.81
Feed Intake (kg/herd/day, fresh)		
Concentrate (kg)	8	-
TMR (kg)	7.5	7.5
Grass (Pasture) (kg)	-	20
Hay (Timothy: Breakaway ryegrass 2:8) (kg)	8	1

*Values are expressed as mean ± SEM of 8 dairy cows in each group.
[a,b]Denotes the comparisons made between the rows.

especially during the summer, resulted in lower milk performance and lactation persistence than in the indoor-based feeding system. The findings of the current study suggest that the pasture-based feeding cows were not able to exploit their genetic milk performance potential, which confirms the results of Holstein cows with a slightly higher level of concentrate (Fulkerson et al. 2008). Additional feeding with energy-rich, which would not be consistent with a low-cost, self-sufficient pasture-based feeding system. Moving the cows to grass pasture might also be a management option to compensate such summer feed lack. Indeed, this is common practice in grass and pre-grass regions.

Ⅳ. CONCLUSIONS

The novelty of this study the real-time comparison of 2 distinct feeding system widely practiced in Korea on dairy

Table 3 Milk composition between indoor and pasture-based feeding systems of Holstein dairy cows

#Milk compositions (%)	Indoor			Pasture		
	Mean	SEM	p-value	Mean	SEM	p-value
Fat	4.00	1.46	0.05	4.81	1.48*	0.05
Protein	3.62	0.44	0.05	3.26	0.09ns	0.05
Lactose	4.77	0.15	0.05	4.59	0.28ns	0.05
Citric acid	2.86	0.32	0.05	2.75	0.20ns	0.05
Total solids	13.11	1.45	0.05	13.39	1.72ns	0.05

#Values are expressed as mean ± SEM of 8 dairy cows in each group.
*,nsDenotes the comparisons made between the rows.

Table 4 Milk mineral contents in indoor and pasture-based feeding systems of Holstein dairy cows

Mineral contents (mg/kg)	Indoor			Pasture		
	Mean	SEM	p-value	Mean	SEM	p-value
Calcium	1097.18	117.57	0.05	1043.96	46.95ns	0.05
Phosphorus	853.87	83.42	0.05	794.98	51.62ns	0.05
Potassium	30.61	11.80	0.05	19.45	7.39ns	0.05
Magnesium	104.08	19.57	0.05	92.61	4.51ns	0.05
Zinc	2.90	0.75	0.05	2.79	0.24ns	0.05
Iron	1.13	0.18	0.05	1.76	0.48ns	0.05

Values are expressed as mean ± SEM of 8 dairy cows in each group.
*,nsDenotes the comparisons made between the rows.

Table 5 Milk fatty acids contents in indoor and pasture-based feeding systems of Holstein dairy cows

$Fatty acids contents (%)	Indoor			Pasture		
	Mean	SEM	p-value	Mean	SEM	p-value
Myristicacid (C14:0)	11.75	0.71	0.05	10.94	1.00ns	0.05
Palmiticacid (C16:0)	38.04	1.55	0.05	37.10	1.54ns	0.05
Palmitoleicacid (C16:l)	1.58	0.26	0.05	1.47	0.02ns	0.05
Stearicacid (C18:0)	15.61	1.90	0.05	17.75	1.36ns	0.05
Oleicacid (C18:l)	28.64	2.14	0.05	28.63	1.72ns	0.05
Linoleicacid (C18:2)	3.39	0.29	0.05	3.10	0.33ns	0.05
γ-Linoleicacid (C18:3)	0.12	0.03	0.05	0.13	0.03ns	0.05
Linolenicacid (C18:3)	0.30	0.04	0.05	0.30	0.05ns	0.05
Eicosenoicacid (C20:l)	0.38	0.02	0.05	0.36	0.03ns	0.05
Arachidonicacid (C20:4)	0.19	0.05	0.05	0.22	0.05ns	0.05

$Values are expressed as mean ± SEM of 8 dairy cows in each group.
*,nsDenotes the comparisons made between the rows.

cows over a full lactation period. In conclusion, Holstein cows raised in indoor-based feeding system have been shown a greater benefit, and it is more efficient than pasture-based feeding system. Moreover, the use of indoor-based feeding system resulted in a greater benefit in body weight gain in Holstein cows, and it is more efficient than pasture feeding systems. The indoor-based feeding system used also had a direct effect on milk yield, composition, the content of total saturated and unsaturated fatty acids. Finally, this study further indicated the possibility of mineral and fatty acids content of milk of indoor-based feeding system over that of pasture-based feeding system in Holstein cows.

Ⅴ. ACKNOWLEDGEMENT

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