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Efficacy of PCDairy application in optimal ration formulation for milking cows on milk productivity and quality

Nguyen Thanh Hai[1*] and Diep Tan Toan[2]

[1]*Nong Lam University, Ho Chi Minh City, Vietnam*

[2]*Dairy Demonstration and Experimental Farm with High Technology, Ho Chi Minh City, Vietnam*

**Correspondence: Nguyen Thanh Hai (email: hai.nguyenthanh@hcmuaf.edu.vn)*

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ABSTRACT

The aim of this study was to evaluate the efficacy of PCDairy application in optimal ration formulation for milking cows on milk productivity and quality at the Dairy Demonstration and Experimental Farm with High Technology in intensive large farming conditions in Ho Chi Minh City, Vietnam from February to May 2019. The experiment was arranged into a randomized complete block design with two rations (control treatment with cows fed the current farm-based ration and PCDairy treatment with cows fed the PCDairy corrected ration) and lasted three months. Total of 56 Holstein Friesian crossbred cows at the 2nd and 3rd parities were divided into two treatments. The results showed that the average milk yield of cows fed the current farm-based ration (control) was 26.59 kg/cow/day and lower than that of cows fed the PCDairy corrected ration (PCDairy) of 29.48 kg/cow/day ($p<0.05$). There was a tendency to improve milk quality indicators (fat, protein and solid-not-fat) ($p>0.05$). Dry matter intake/kg milk of cows in control treatment (0.75 kg DMI/kg milk) was higher than that of PCDairy treatment (0.69 kg DMI/kg milk) ($p<0.05$). The cost of feed/kg milk decreased about 10.89% in PCDairy treatment. The rate of digestive diseases of cows fed the current farm-based ration (10.71%) did not differ from that of cows fed the PCDairy corrected ration (7.14%) ($p>0.05$). In brief, PCDairy application improved milk yield and DMI/kg milk, as well as reduced feed cost.

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1 INTRODUCTION

In recent years, the dairy industry has developed strongly with intensive large scales, many farms with thousands of dairy cows. On 1st October 2018, the whole Vietnam dairy herd was 294,382 heads, particularly Ho Chi Minh City with a total of 81,280 heads (General Statistic Office, 2019). According to consumption trend, the demand for milk consumption of Vietnamese is increasing with 23 liters/person/year in 2015, 24 liters/person/year in 2016, and 26 liters/person/year in 2017. According to the forecast of Industry and Trade Ministry, the milk consumption per person will continue to increase and

may reach 28 liters/person/year in 2020. However, the domestic milk production volume is still too low with only about 30% of Vietnamese demand (Thanh Hai, 2019).

In 2014, the value of imported milk reached 1,100 million USD which was the highest among livestock products. In 2016, the whole country exported 11.08 thousand tons of pasteurized fresh milk, the exported turnover reached 17.11 million USD. Therefore, in order to reduce the imported level and increase the exported value, the key point is to promote the development of dairy herds and enhance the milk productivity and quality which are essential for our dairy industry (Doan Xuan Truc, 2016). In addition to issues of breeding, houses, veterinary, caring and rearing, nutrition is a very important factor to be concerned. However, the issue of balanced nutrition in dairy farms today remains a problem for many dairy farmers in order to achieve high efficiency in dairy husbandry. It is essential to find the optimal ration to improve the dairy production capacity, reduce the cost of raising cows, and improve the economic efficiency. It requires specific calculations in both economic and technical terms to find the optimal ration to meet the needs of dairy cows and achieve the highest economic efficiency in current condition of dairy husbandry.

PCDairy application in dairy production would be demonstrated to help dairy farmers increase profits by estimating milk yield based on balancing rations for cows with the suitability of available ingredients, feed price and milk productivity (UCDAVIS, 2015). It also analyzes the nutritional contents of the farm set-up rations, dry matter intake, milk production and daily feeds' cost (Chi Nguyen, 2016). Evaluating and optimizing of nutritional rations for dairy cows during the lactation period with PCDairy software is to improve milk yield and quality, reaching the peak of the lactation cycle which results in minimizing the weight reduction in the early stage of lactation circle and livestock cost. Therefore, understanding efficacy of PCDairy application in optimal ration formulation of dairy husbandry under natural production condition in Vietnam is important because this will help apply this software more popular and appropriate for local dairy production.

2 MATERIALS AND METHODS

2.1 Location

The experiment was conducted at the Dairy Demonstration and Experimental Farm with High Technology, Ho Chi Minh City, Vietnam from February to May 2019.

2.2 PCDairy software

PCDairy is a package of computer programs. This software is a program that contains a library of many animal feedstuffs, of full nutritional value, and thus allowing the formulation and evaluation of daily ration for dairy cows, dry cows and heifers (UCDAVIS, 2015). It helps formulate and analyze the ration for dairy cows which is provide by University of California Davis, modified by the US Department of Agriculture, the Ministry of Agriculture and Rural Development and University of California Davis for appropriate use in Vietnam since being launched in the training program in 2015. PCDairy formulates the optimal cost ration for milking, dry and growing cows with a feed library that contains the full nutrients of different types of feedstuffs which are available and used in Vietnam at the lowest cost. This software can be updated by the user with local available feedstuffs and market price as well as cows' information (e.g weight, milk yield and etc.) (Chi Nguyen, 2016).

2.3 Experimental design, animals and housing

The study was arranged into a randomized complete block design (block: month in lactation cycle) with two treatments of rations. The treatments included (1) control with cows fed the current farm-based ration and (2) PCDairy with cows fed the PCDairy corrected ration. The cows were housed in the same loose barn containing sand and sawdust on house floor with all cows having free access to water. The study was conducted on a total of 56 Holstein Friesian (HF) crossbred cows with at least 7/8 HF blood, with parities at the 2nd and 3rd, divided into two treatments with 28 cows/treatment, and lasted three months. Cows in two treatments prior to the experiment period were almost equal at parity, live weight and milk yield ($p > 0.05$; Table 1).

Table 1: Experimental design

Treatment	Control (Current farm-based ration)	PCDairy (PCDairy corrected ration)
Cows (n)	28	28
The 1st–3rd months in lactation cycle (cows)	10	10
The 4th–6th months in lactation cycle (cows)	10	10
The 7th–10th months in lactation cycle (cows)	8	8
Parity (*p = 0.350*)	2.46 ± 0.45	2.50 ± 0.44
Live weight (kg/cow) (*p = 0.820*)	526.54 ± 28.6	538.82 ± 24.9
Milk yield (kg/cow/day) (*p = 0.762*)	25.39 ± 24.4	25.53 ± 26.2

2.4 Daily ration of cows

All cows were fed twice a day (7:45 and 14:15 every day, *ad libitum*) as Total Mixed Ration method (TMR). TMR is a method of feeding cows that combines feeds formulated with specific nutrients into a complete feed mixture. It contains the roughage (forage, silage, hay), concentrate (grains, complete feed, by-products) and vitamins, minerals, which are the most suitable for dairy cows with the balanced and adequate diet of nutrients such as energy, protein, minerals and vitamins (Lammers *et al*., 2016).

TMR feed was available at all positions of feeding trough that cows could eat and thus meeting the demand with consumption amount as Table 2. All cows were adapted to experimental condition in seven days in advance. All cows were washed and cleaned three times a day.

Table 2: Ingredients in two rations

Ingredients	Unit	Control (Current farm-based ration)	PCDairy (PCDairy corrected ration)
King grass	%	22.33	29.30
Alfafa grass	%	1.41	1.58
Mulato grass	%	5.88	9.02
Corn silage	%	36.12	22.54
Corn grain	%	3.06	1.13
Rice bran	%	0.47	1.13
Soybean meal	%	1.65	0.45
Complete powder	%	26.82	24.79
Rumifat flus	%	1.10	1.06
Brewers grain	%	1.18	2.25
Molasses	%	0.00	6.76
Total	%	100.00	100.00

Table 3: Daily ration value in two treatments

Value	Control	PCDairy
Dry matter intake (%)	3.59	3.76
NEL for milk production (kg)	27.0	30.0
CP for milk production (kg)	32.0	30.0
Crude protein (%)	15.79	14.26
NDF (%)	32.59	31.32
Fat (%)	5.79	5.48
NFC (%)	35.19	37.69
Starch (%)	30.02	24.01
Ca:P	1.12	1.42

The nutrients of ingredients in rations were analyzed at the testing and analyzing laboratory of breed of the Center for Plant, Livestock and Aquaculture Breeds. The daily ration value of the two rations were analyzed by PCDairy and based on the nutritional requirements of NRC (2001) for lactating

dairy cows. In Table 3, it showed that the current farm ration for starch (30.02%) was higher than the demand for dairy cows (23 - 25%) and the ratio of Ca:P (1.12) was lower than demand (≥ 1.3). Besides, energy (NEL) for milk production (27 kg) was not balanced with protein for milk production (32 kg) and resulted in actual milk production of limitation by the energy value (NEL) of 27 kg. As a consequence, the current farm-based ration was not optimal. In contrast, PCDairy corrected ration for dry matter intake (3.76%), NEL and protein for milk production which were balanced and could reach the milk yield of 30 kg. Moreover, major nutritional compositions in PCDairy ration were appropriate with NRC (2001) recommendations for dairy cows with CP (14.26%), NDF (31.32%), fat (5.48%), starch (24.01%), NFC (37.69%). Therefore, the application of PCDairy software in dairy nutrition management can achieve the adequate and balanced rations of nutrients (NRC, 2001) affecting positively on the nutritional needs of dairy cows and resulting in higher economic efficiency in theory as PCDairy software's analysis.

2.5 Sample collection and measurements

Milk yield (kg/cow/day): All cows were milked by milking system into specialized container three times a day (6:00, 14:00 and 21:00), using the recording machine in milking system, and then merging three times into the average milk yield/cow/day.

Milk quality: Take one milk sample per cow at the end of the month (the second milking time at 14:00), 56 milk samples per month to analyze milk quality including milk fat, milk protein and milk solid-not-fat for 56 individual cows in two treatments. The sampling method of raw fresh milk was carried out according to TCVN 6400:2010 with 200 ml/sample. Milk samples must be stored in a cool condition at 2 - 6°C and transported quickly to the laboratory. The milk quality indicators were quickly analyzed by Ekomilk Total machine which had the result in about 60 seconds/sample in the testing and analyzing laboratory of breeds, Center for Plant, Livestock and Aquaculture Breeds.

Dry matter intake per kg milk (DMI/kg milk): All cows were fed 4% DMI (21 kg DM/cow/day, about 52.5 kg TMR/day contained 40% DM) of body weight (exceeded 3 - 3.5% DMI requirement according to NRC, 2001) and refusal feed was collected for calculation the DMI/kg milk. Then, apply the equation to calculate DMI/kg milk as the total dry matter intake per day each treatment divided by the total milk yield each treatment.

Feed cost per kg milk (VND): Feed cost for producing 1kg of milk was calculated as total cost of ration (VND) divided by cow's milk production per day (kg).

Digestive diseases: All cows were observed and recorded about all issues related to digestive diseases in the experimental period to calculate the percentage of digestive diseases per treatment. In particular, the percentage of digestive diseases (%) was calculated as the numbers of digestive disease cows in experiment period divided by the total cows each treatment x 100. Indication signals of digestive diseases were from feces with the height, color, consistency, bubbles, mucous, foamy and grain (Hall, 2002; Heinrichs *et al*., 2016).

2.6 Statistical analysis

Data were analyzed as a randomized complete block design by ANOVA using the GLM procedure of Minitab Software version 16.2. The individual cow was considered experimental unit for the all parameters. The average values were compared by the Tukey test and the percentages were compared by the χ^2 test, the differences were considered significant at $p \leq 0.05$.

3 RESULTS AND DISCUSSION

3.1 Milk yield (kg/cow/day)

The average milk yield per day of cows fed the current farm-based ration (control) was 26,59 kg/cow/day and lower than that of cows fed the PCDairy corrected ration (PCDairy) of 29.48 kg/cow/day (p = 0.030; Table 4), a growth of 2.89 kg/cow/day (approximately 10.87%). This result showed that the use of PCDairy in ration formulation helped improve the milk yield of dairy cows which was appropriate with the perspectives of Bath and Ahmadi (2016). The reason was that the ration adjusted by PCDairy was balanced with adequate suitable nutrients to the needs of dairy cows such as energy, protein, fat, crude fiber, neutral detergent fiber (NDF), acid detergent fiber (ADF), starch, none-fiber carbohydate, macrominerals and microminerals. Therefore, when cows are provided with adequate and balanced nutrients, the milk yield of cows are improved (Garg, 2012).

Table 4: Effect of two rations on the average milk yield during experimental period

Treatment/Milk yield	n (cows)	$\overline{X}$ ± SD (kg/cow/day)	CV (%)	SEM	*p*
Control	28	$26.59^{a} \pm 5.57$	20.95	0.08	0.030
PCDairy	28	$29.48^{b} \pm 5.19$	17.60		

[ab]Means in the same column without common letter are different at $p \leq 0.05$

3.2 Milk quality (%)

The percentage of milk fat of cows fed the current farm-based ration (control) was 3.56% and not different from that of cows fed the PCDairy corrected ration (PCDairy) of 3.60% ($p = 0.981$; Table 5). The rate of milk protein of cows fed the current farm-based ration was 3.94% and not different from that of cows fed the PCDairy corrected ration of 3.95% ($p = 0.924$). The ratio of solid-not-fat (SNF) in milk of cows in the control treatment was 10.17% and not different from that of cows in the PCDairy treatment of 10.18% ($p = 0.970$). Although milk quality (fat, protein and solid-not-fat) did not differ significantly between the two treatments ($p > 0.05$), there was a tendency to improve milk quality in all three indicators.

Table 5: Effect of two rations on the milk compositions during experimental period

Treatment/Milk compositions	Control	PCDairy	SEM	*p*
n (cows)	28	28		
Milk fat	3.56 ± 1.63	3.60 ± 1.68	0.32	0.981
Milk protein	3.94 ± 0.39	3.95 ± 0.32	0.07	0.924
Solid-not-fat	10.17 ± 1.04	10.18 ± 1.01	0.20	0.970

3.3 Dry matter intake per kg of milk (kg DMI/kg milk)

Dry matter intake per kg milk of cows fed the current farm-based ration (control) was 0.75 kg DMI/kg milk and higher than that of cows fed the PCDairy corrected ration (PCDairy) of 0.69 kg DMI/kg milk ($p = 0.039$; Table 6), a reduction of 0.06 kg DMI/kg milk (about 8.0%). The application of PCDairy software in dairy nutrition management could achieve the adequate and balanced rations of nutrients. As a result, it helped increase dry matter intake per day from 3.59% to 3.76%, as well as optimized the major nutritional compositions for dairy cow's requirement (CP, NDF, ADF, starch, NFC, Ca:P) (Table 3). Therefore, this application improved better microorganisms' activities in rumen and higher feed efficiency, resulting in improvement dry matter intake/kg milk (Garg, 2012; Bath and Ahmadi, 2016).

Table 6: Effect of two rations on the dry matter intake/kg milk (kg DMI/Kg milk)

DMI/kg of milk	n (cows)	$\overline{X}$ ± SD (kg DMI/kg milk)	CV (%)	SEM	*p*
Control	28	$0.75^{a} \pm 0.13$	17.19	0.02	0.039
PCDairy	28	$0.69^{b} \pm 0.12$	16.59		

[ab]Means in the same column without common letter are different at $p \leq 0.05$

3.4 Feed cost per kg of milk (VND/kg milk)

Under experimental conditions, based on the results of calculation of ingredients' use in control treatment (the current farm-based ration) and PCDairy treatment (PCDairy corrected ration) as well as the average milk yield and cost of raw ingredients at the studying time to calculate feed cost/kg milk which aimed to assess the economic efficiency of PCDairy software application for milking cows.

Feed cost for producing 1 kg milk of cows fed the current farm-based ration (Control) was 6,390 VND and higher than that of cows fed the PCDairy corrected ration (PCDairy) of 5,694 VND (Table 7), a reduction of 696 VND. This indicated that the use of ration recommended by PCDairy would be more economically effective than the current farm-based ration with the reduction of 10.89% in feed cost/kg milk. Therefore, PCDairy application helped minimize feed cost and resulted in maximizing the profit in dairy production (Bath and Ahmadi, 2016; Chi Nguyen, 2016).

Table 7: Effect of two rations on feed cost/kg milk (VND/kg milk)

Ingredients	Price/kg (VND)	Control		PCDairy	
		Quantity (kg/day)	Total amount (VND)	Quantity (kg/day)	Total amount (VND)
King grass	500	9.50	4,750	13.00	6,500
Alfafa grass	6,800	0.60	4,080	0.70	4,760
Mulato grass	500	2.50	1,250	4.00	2,000
Corn silage	2,000	15.37	30,740	10.00	20,000
Corn grain	7,100	1.30	9,230	0.50	3,550
Rice bran	6,300	0.20	1,260	0.50	3,150
Soybean meal	15,000	0.70	10,500	0.20	3,000
Complete powder	8,100	11.41	92,421	11.00	89,100
Rumifat flus	27,000	0.47	12,690	0.47	12,690
Brewers grain	6,000	0.50	3,000	1.00	6,000
Molasses	5,700	-	-	3.00	17,100
Feed cost/cow/day			169,921		167,850
Feed cost/kg milk			6,390		5,694

3.5 Digestive diseases (%)

This is an important indicator to assess the health status of cows during the experiment in specific and the practice in general. During the experimental conducting period, there were two cases of diarrhears with bubbles in feces and one case of rumen acidosis in the control treatment which accounted for 10.71% and were not different from those of PCDairy treatment which had two cases of diarrhears with bubbles in feces which accounted for 7.14% (p = 0.930; Table 8). In addition to the above diseases, there were not any signals of other diseases related to gastrointestinal tract such as the rumen bloat or digestive disorder in the experimental period. This showed that the cows were healthy with PCDairy corrected ration, leading to no adverse effects on milking cows with PCDairy formulation application in practice.

Table 8: Effect of two rations on the rate of digestive disease during experiment (%)

Treatment/Digestive disease	n (cows)	Cows with digestive disease	Percentage of digestive disease (%)	*p*
Control	28	3	10.71	0.930
PCDairy	28	2	7.14	

4 CONCLUSIONS

The adjusted ration by PCDairy helped increase milk yield and feed efficiency as compared with the current farm ration (control). There were no differences in the milk quality indicators and gastrointestinal diseases between two treatments. In addition, it reduced the feed cost per kg milk in comparison with Control. Thus, PCDairy would be considered to apply as a potential efficient measure in optimal ration formulation for milking cows to improve production performance and efficiency.

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