Asian Research Journal of Agriculture

5(2): 1-7, 2017; Article no.ARJA.33663
ISSN: 2456-561X

The Effects of Total Mixed Ration and Separate Feeding on Lactational Performance of Dairy Cows

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Authors' contributions

This work was carried out in collaboration between all authors. Author MG designed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript. Author MEMAM carried out the experiment with cows. Author SG managed the literature searches and wrote the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARJA/2017/33663
Editor(s):
(1) Fábio da Costa Henry, Laboratory of Food Technology, State University of Northern of Rio de Janeiro, Brazil.
Reviewers:
(1) Sabri Gül, Mustafa Kemal University, Hatay, Turkey.
(2) Marcio Da Silva Vilela, Federal Institute of Maranhão, Brazil.
Complete Peer Review History: http://www.sciencedomain.org/review-history/19843

Original Research Article

Received 25th April 2017
Accepted 28th June 2017
Published 4th July 2017

ABSTRACT

The aim of this study was to investigate the effects of different feeding systems on milk production and milk composition of dairy cows. Thirty-two dairy cows having similar lactation number, Days in Milk (DIM), live body weight and milk production was divided into four groups. First group received Total Mixed Ration (TMR) ad libitum, second group received roughage and concentrate limited and separately in two meals, third group fed with partial TMR which included half of the concentrate in roughage part of the diet and remained concentrate was offered in two meals, and the last group was fed with roughage and concentrate separately and roughage was offered limited in two meals and concentrate was offered limited in four meals. The feeding systems affected dry matter intake ($P<0.05$). Limited feeding groups were fed on roughage and concentrate separately, the roughage intake in these groups was decreased, concentrate ratio was increased in the diet as well especially in the group receiving concentrate in two meals ($P<0.05$). In TMR group, milk yield was significantly increased due to increase in their feed intake ($P<0.05$, 2 kg/day higher than others). Milk total solid, fat and urea nitrogen contents were affected by feeding systems. Restricted and separate feeding system groups had lower total solid, fat and urea nitrogen in milk ($P<0.05$). In conclusion, the results showed that restricted and separate feeding of concentrate and roughage may not be applicable in practice as it decreased feed intake, milk yield and milk fat test.

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Keywords: Feeding systems; milk yield; milk composition; dairy cows.

1. INTRODUCTION

Different feeding systems are available for dairy cow in practice such as standard feeding, strategic feeding, feeding complete diet (Total mixed ration: TMR) [1,2], strategic or partial TMR [2], and choice (cafeteria) feeding [3]. Standard feeding refers feeding dairy cows according to current milk yield and live weight. In which all feeds are supplied restricted, individually and separately to the animal. In strategic feeding, concentrate is used restrictively and independent from milk yield and roughage is used ad libitum. This system may be applied by using concentrate in constant amount in early lactation and later may be decreased according to milk yield as well. Concentrate may be also supplied by milking system or automatic station feeder in strategic feeding. Complete feeding (TMR) is applied by mixing concentrate and roughage with mixer and delivered to animal ad libitum. Strategic TMR is a mixture of strategic and TMR feeding systems. TMR may not cover nutrient requirements of high yielding cows and extra concentrate can be supplied in automatic station feeder. This could be applied as partial TMR to overcome the ruminal problem due to high and separate concentrate usage. Recently choice feeding (supplying feed ingredient separately, simultaneously and ad libitum) is considered as a feeding system for small ruminants [4,5,6,7], and some studies are also available in dairy cattle [8,3].

Main differences of these feeding systems are ways of supply of concentrate and level of feeding (restricted or ad libitum). Increasing concentrate in the diet or using separately may reduce rumen pH and digestibility of dietary fiber [9,10]. TMR is a proper feeding system to solve problem with low ruminal pH which is having a negative effect on the microbial growth and milk fat content [11,12,13]. Similarly, free choice feeding, offers a chance to the animals to select their diet [4,8,14,15] and balance rumen condition [14,3], and thus it may have a potential advantage in ruminant feeding. Other ways of alleviating separate concentrate usage are to increase concentrate feeding frequency or use some of concentrate with roughage such as in partial TMR and/or strategic TMR application.

Shabi et al. [16], revealed that high concentrate and highly degradable starch using in diet may increase fluctuation of rumen pH, ruminal ammonia, volatile fatty acids and these fluctuations may be controlled and milk yield and the components may be improved by increasing feeding frequency from 2 to 4. Similarly, Devries et al. [17] reported that increasing feeding frequency from 1 to 4 times may decrease sorting and variation of consumed diet. However, some researchers [18,19], reported better results with single feeding compared to frequent feeding. They explained the results with increase aggressive behavior and less time for resting during feed delivery with frequent feeding.

Generally, small dairy farms supply concentrate during milking separately from the roughage and all feeds supplied restricted. Much of the milk production is supplied by these types of farms especially underdeveloped and developing countries. Thus, it is very important to show the effects of limited and separate feeding of concentrate. The present study was therefore aimed to test ad libitum TMR, standard feeding, restricted feeding with partial TMR and concentrate and restricted feeding with roughage and restricted but frequent feeding of concentrate on milk yield and milk composition of dairy cows.

2. MATERIALS AND METHODS

Study was carried out in Dairy Farm at Cukurova Universitiy, Faculty of Agriculture, Department of Animal Science located 37°02′37″N, long. 35°22′21″E, approximately 127 m above sea level, from January to February, 2014 and lasted 8 weeks. The climate in this region is relatively warm, with a mean temperature of about 12°C and relative humidity 66%. Thirty-two lactating Holstein cows were divided into four feeding regimes in a Completely Randomized Design according to their milk yield, parities, and body weights. The cows had about 75 days in milk and 34 kg milk yield, 555 kg average body weight. Animals were housed and maintained according to the approval of animal care and use Ethical Committee of Cukurova University during the trial.

A standard TMR (Table 1) were formulated according to NRC [20] with about 22 kg DM/day and the four feeding regimes were designed according to this TMR and dry matter intake. Feeding regimes were 1) ad libitum TMR in two meals, 2) roughage and concentrate in standard TMR were supplied separately and restrictedly in two meals (standard feeding), 3) half of concentrate in standard TMR were included to

Table 1. Standard diet used in ad libitum TMR and the diet consumed in different feeding regimes (%)

Roughage	Ad libitum TMR	R2X	RpTMR2X	R2X
Concentrate		**C2X**	**C2X**	**C4X 4 Meal**
Corn	18.44	19.10	18.35	18.67
Barley	5.00	5.19	5.00	5.09
Beet molasses	1.20	1.23	1.20	1.21
Sunflower meal	11.09	11.48	11.05	11.22
Fulfat soybean	7.50	7.78	7.50	7.65
Corn gluten meal	2.50	2.55	2.45	2.50
Wheat bran	9.20	9.57	9.20	9.35
Soy oil	0.60	0.64	0.63	0.64
Alfalfa hay	16.40	15.58	16.50	16.10
Corn silage	26.20	24.87	26.30	25.69
Limestone	0.90	0.94	0.90	0.93
Dicalcium phosphate (DCP)	0.60	0.60	0.57	0.58
Salt	0.20	0.21	0.20	0.21
Sodium bicarbonate	0.16	0.17	0.16	0.17
Vitamin-Mineral Premix	0.09	0.09	0.08	0.08
Nutrient content;				
Dry Matter, %	61.83	62.88	61.80	62.25
Net Energy (NEl), Mcal/kg DM	1.58	1.60	1.60	1.60
Crude protein (CP), %DM	16.89	17.09	16.90	16.98
MP, %DM *	10.75	10.77	10.67	10.73
Rumen Undegradable Protein (RUP),%DM *	5.93	5.87	5.76	5.85
Rumen Degradable Protein (RDP), %HP *	65.25	65.64	65.90	65.56
Fat, %DM	4.60	4.66	4.58	4.63
Ash, %DM	6.98	6.99	6.97	7.00
Neutral Detergent Fiber (NDF), %DM	35.40	34.97	35.44	35.22
Acid detergent Fiber (ADF),%DM	21.95	21.51	21.98	21.77
Non Fiber Carbohydrate, %DM	38.57	38.70	38.51	38.57
Lysine, %MP *	5.96	6.00	6.03	6.01
Methionine, %MP *	1.93	1.94	1.94	1.94
Lysine/methionine *	3.10	3.10	3.11	3.10

*R2X: Restricted and 2 meals, R4X: Restricted and 4 meals, RpTMR2X: Restricted partial TMR and 2 meals, *NRC [20] supply*

roughage to construct a partial TMR (pTMR) and partial TMR and remaining concentrate were supplied to cows restricted and separately in two meals 4) roughage in standard TMR were supplied in two meals and concentrate were supplied in 4 meals, separately and restrictedly. The cows were kept in individual paddock having 3 x 6 m size. The cows fed in two meals received their diet at 06:00 and 18:00 and the cow fed in four meals received their diet at 06:00, 12:00, 18:00 and 24:00. Fresh water was available freely.

Chemical compositions of feed ingredients were determined according to the standard Official Methods of Analysis (AOAC) [21]. Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were analyzed by using ANKOM fiber analyzer [22]. Ingredient composition of single fed diet and its chemical contents are given in Table 1. Live weight change was determined weekly and milk yield and feed intake were determined daily. Animals were milked at 05:00 in the morning and at 17:00 in the afternoon and milk samples were taken from morning and afternoon milk and analyzed by MilkoscanFT-120 (Foss, DK) weekly and their compositions were recalculated according to portion of morning and afternoon milk in the total milk.

The study was carried out in a completely randomized design and data were analyzed GLM procedure of SAS [23] and means were separated with Duncan Multiple Range Test.

3. RESULTS AND DISCUSSION

The standard TMR was formulated according to the age, the initial live weight, the condition score and the milk yield of the cows and environmental conditions. All concentrates supplied were consumed in the groups fed separately but roughages were not consumed totally in those groups although roughages were supplied limited amount. High concentrate intake resulted in decrease roughage intake in other studies [26,27,28,30], when concentrate and roughage were supplied separately. Thus roughage/concentrate ratio of the diets for separate feeding groups was changed. Ad libitum TMR had 43.5% roughage, but the cows receiving concentrate separately except partial TMR groups increased concentrate ratio in the diet significantly (P<0.01). The cows fed with ad-libitum TMR consumed more dry matter and nutrients as expected and this resulted in increase in milk yield (P<0.05) compared to separate feeding groups. High feed intake in TMR feeding groups increased body weight gain due to better energetic status compared to the other feeding groups.

It is well known that ad libitum TMR feeding increase feed intake and may improve lactation performance [13,24] as the system provides more stable rumen environment and supply synchrony in nutrients for rumen microorganisms and the host animal [24,25].

As noted before, separate feeding decreased roughage intake and increased concentrate in their diets [26,27,28]. It is well known that high concentrate may improve nitrogen utilization efficiency in the rumen [20,29], and may decrease milk urea nitrogen as found in this study. Agnew et al. [30] reported that high concentrate increased nitrogen utilization efficiency and protein content of milk. Similarly Godden et al. [31], revealed that milk urea nitrogen concentrations had a positive relationship with dietary levels of Crude protein (CP), Rumen Degradable Protein (RDP), and Rumen Un degradable Protein (RUP), and a negative relationship with levels of Non Fiber Carbohydrate (NFC), and with the ratios of NFC:CP, NFC:RDP, NFC:RUP. Accordingly, the cows fed with separate and restrictedly increased concentrate ratio in the diet and decreased milk urea nitrogen in the present study.

Separate feeding decreased roughage content of the diets consumed this is the basic reason of low milk fat test in many dairy farms.

Table 2. Lactational performance of the cows fed different feeding regimes

Roughage	Ad libitum	R2X	RpTMR2	R2X	SEM	(P<)
Concentrate	TMR	R2X	R2X	R4X		
Roughage, % DM	43.5a	40.7b	42.2ab	41.7b	0.01	0.01
Body weight change, kg	22.2a	5.0b	-4.3b	6.3b	6.16	0.04
Milkyield, kg/day	34.4a	32.6b	31.8b	32.8b	0.52	0.02
Milk yield change, kg	1.5a	-1.4b	-2.2b	-1.8b	0.73	0.01
Dry matter intake, DMI,kg/day	23.4a	21.2b	20.8b	21.2b	0.51	0.01
MPE (MilkYield/DMI)	1.5	1.5	1.5	1.6	0.04	0.59
Milk compositions;						
Dry Matter, %	12.18a	11.19b	11.25b	11.22b	0.48	0.02
Fat, %	3.31a	2.14b	2.21b	2.31b	0.55	0.01
Protein, %	3.14	3.31	3.22	3.14	0.08	0.50
Lactose, %	4.75	4.67	4.77	4.72	0.04	0.70
Casein, %	2.55	2.61	2.58	2.52	0.04	0.80
Urea-N, mg/dL	19.2a	16.2b	19.1ab	20.1a	1.70	0.02
Nutrient intakes;						
NEL, Mcal/day	36.6	34.2	33.1	34.3		
Rumen Undegradable Protein, g/day	1375	1256	1191	1254		
Crude protein (CP), g/day	3914	3655	3492	3643		
Neutral Detergent Fiber (NDF kg/day)	8.2	7.3	7.3	7.6		
Acid Detergent Fiber (ADF) kg/day	5.1	4.6	4.5	4.7		

MPE: Milk production efficiency, R2X: Restricted and 2 meals, R4X: Restricted and 4 meals, RpTMR2X: Restricted partial TMR and 2 meals

Many studies [32,33,34,35] reported that high concentrate diet may decrease rumen pH, cellulose digestibility and acetate/propionate ratio in the rumen causing lower milk fat test. On the other hand, the amount of concentrate supplied in separate feeding is another issues for ruminal fermentation, high starch load in a short time may interfere the ruminal condition and aggravate low milk test [36,37,38]. High concentrate and high starch load to rumen may decrease acetate (ruminal effects), [24] production which is main precursors of de novo milk fatty acid synthesis in mammary tissues and increase trans C18:1 fatty acid in the rumen [39,40,41,35], during biohydrogenation of polyunsaturated fatty acids in the rumen known as inhibiting enzymes (post ruminal effect) [42,43], for milk fatty acid synthesis in mammary tissues.

Frequent feeding with concentrate or partial TMR use to limit the load of concentrate to rumen are alternatives approaches to minimize negative effects of separate feeding. Some researchers [44,45,46], reported better feed intake and improvements in milk protein and fat contents with frequent feeding, but some others [47,48,49,50], did not observe any differences, and Fan et al. [51], revealed that ad libitum roughage and 4 times concentrate supply was better feeding regimes for dairy cows during warm season. However, frequent feeding with concentrate or partial TMR usage did not improve any performance parameters of the dairy cows in the present study. There are marked variations of the results obtained with different feeding systems. These could be attributed to genotypes, milk yield, stage of lactation, season, feed sources and quality, and amount of concentrate used daily. TMR feeding is a good practice for many dairy farms and has higher milk yield and more stable milk components [13,24] compared separate feeding regimes such as in the present study.

4. CONCLUSIONS

The results showed that separate feeding regimes under restricted feeding conditions were not advisable for practice as it decreased feed intake, and roughage/concentrate ratio, milk yield and milk fat test significantly.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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