*Indian Journal of Animal Sciences* **89**(7): 768–773, July 2019/Article
https://doi.org/10.56093/ijans.v89i7.92043

# Effect of shortening close-up period length with or without lasalocid supplementation on production performance of dairy cows*

PEJMAN ATRIAN[1], HAMID AMANLOU[2], NASER MAHERI-SIS[3] and HABIB AGHDAM SHAHRYAR[4]

*Islamic Azad University, Shabestar, Iran*

Received: 10 May 2018; Accepted: 3 December 2018

ABSTRACT

To determine the effect of shortening the close-up period length with or without lasalocid supplementation on dry matter intake (DMI) as well as milk production and composition, 48 dry Holstein cows with 700±50 kg live body weight, 3–5 years old and BCS=3.75±0.25, in 210 days of pregnancy, were used. The experiment was planned as a completely randomized design with a 4×12 arrangement of treatments. Control group cows (21-L) had 21 days close-up dry period without lasalocid, second group (21+L) had 21 day close-up with lasalocid, third group (10-L) had shortened close-up dry period without lasalocid and last group (10+L) had shortened close-up period associated with lasalocid. The experiment started from inception of dry period and finished at the end of 42 days in milk (DIM). Results showed that although shortening of the period length associated with the use of lasalocid, could not alter prepartum DMI, but significantly increased postpartum DMI and milk production, improved feed conversion ratio (FCR), and decreased milk fat and protein content. Hence, shortening of close-up period from 21 days to 10 days associated with lasalocid supplementation resulted in better productivity of dairy cows.

**Key words**: Close up, Dairy cows, Dry matter intake, Feed conversion ratio, Lasalocid, Milk yield

The transition period (3 weeks before and 3 weeks after parturition) is the most stressful time in the production cycle of dairy cattle, because of depressed feed intake, and endocrine and metabolic changes around the calving. At early lactation, because energy intake do not synchronize with energy requirements, therefore cows energy requirements are obtained from body reserves and this tend to body weight losses and negative energy balances (McArt *et al.* 2013, Amirabadi *et al.* 2017). Economic losses of negative energy balance in early lactation, led to treatment costs, increased culling and decreased milk production (McArt *et al.* 2013).

Use of ionophores increases energy metabolism of the rumen microbes and the host animal because of enhanced production of propionate among ruminal fatty acids with a concomitant reduction in methane (Azzaz *et al.* 2015). Dry matter digestibility is increased with ionophores, thereby providing environmental benefits. Hayirli *et al.* (2002) indicated that voluntary DMI of multiparous Holstein dairy cattle decreases about 32% from 21 day pre-partum to 1 day prepartum with the greatest decrease occurring during the last week of gestation. Traditionally close-up period is 21 days, but some researchers are now suggesting that close-up period must be shortened to 10–14 days (Amirabadi *et al*. 2017, 2018).

Nutrition management during close-up period can affect liver lipid concentration and incidence of some of metabolic disorders in early lactation (Douglas *et al.* 2006). Low and high intensity feeding during dry period can exert undesirable effects on milk production in postparturient cows. Inadequate feeding during dry period causes problems such as metabolic disorders and adverse effects on milk production. Fat cows cannot use sufficient feed to obtain their energy requirements and this leads to some of metabolic disorders and DMI reduction after calving (Janovick *et al.* 2010, 2011). Therefore shortening the close-up length promotes dairy cows appetite leading to improved intake of feed after calving; resulting in less adipose tissue mobilization and productivity problems, hence improving post-calving health (Amirabadi *et al*. 2017).

The aim of this study was shortening of the close-up period length from 21 days to 10 days, with or without supplementing lasalocid for improving postpartum DMI and milk yield and composition.

## MATERIALS AND METHODS

*Animals and diets:* Multiparous Holstein dairy cows (48) with 700±50 kg body weight, 3–5 year-old and 3.75±0.25 BCS (1 to 5 scale), were used. These cows were dried off 60 d before their expected parturition date. Three types of rations were fed to experimental cows at 3 phases of study.

*Part of PhD Thesis of first author.

Present address: [1,3,4](pej54atrian@yahoo.com, nama1349 @gmail.com, ha_shahryar@yahoo.com), Department of Animal Science, Shabestar Branch. [2](amanlou@znu.ac.ir), Department of Animal Science, Zanjan University, Zanjan, Iran.

All rations in this experiment were formulated, prepared and offered as per NRC (2001) and cows had free access to water.

The experiment was planned as a completely randomized design with a 4×12 arrangement of treatments. Control group cows (21-L) had 21 days close-up dry period without lasalocid, second group (21+L) had 21 day close-up with lasalocid, third group (10-L) had shortened close-up dry period without lasalocid and last group (10+L) had shortened close-up period associated with lasalocid.

The same far-off ration (Table 1) was fed to all cows in all treatments. At 21 day before expected calving, close-up ration (Table 1) was fed to control and second group, and at 10-day before expected calving, same ration was fed to another 2 groups. To limit energy intake to 100% of NRC (2001) requirements at *ad lib.* intake in close-up period, wheat straw was included as 39.5% of dry matter (far off) for an 11 additional days for 10-L and 10+L cows. The close-up ration was equal for all the cows. At parturition, cows were assigned to a postpartum TMR (Table 1). Within each dietary group, half of the cows received lasalocid before and after parturition (250 and 300 mg/cow at dry and lactation periods, respectively) and half did not. After calving all cows received the same lactation diet (Table 1). Mean TMR quality of each phase is shown in Table 2.

NFC concentration of far-off diets was lower than that of close-up while that of close-up was lower than that of lactation diets. Indeed in this experiment (Table 2), cows in 10-L and 10+L groups, consume lower NFC concentration for longer period (11 d) than control and 21+L groups.

*Collecting data:* Data were collected from a dairy farm.

Table 1. Ingredients of experimental rations offered to the dairy cows (DM basis)

| Ingredients composition (%) | Phase of experiment | | |
|---|---|---|---|
| | Far-off | Close up | Lactation |
| Corn silage | 35.00 | 34.22 | 36.50 |
| Alfalfa hay (chopped) | 0.00 | 3.65 | 8.55 |
| Wheat straw (chopped) | 39.50 | 11.73 | 2.00 |
| Wheat bran | 6.60 | 5.80 | 0.00 |
| Cotton seed | 0.00 | 0.00 | 3.80 |
| Corn (ground) | 0.00 | 9.55 | 16.00 |
| Barley (ground) | 0.00 | 8.13 | 4.55 |
| Soy (hull) | 6.84 | 5.12 | 0.00 |
| Soybean meal (48%) | 6.49 | 6.72 | 5.15 |
| Full fat soya | 0.00 | 0.00 | 5.90 |
| Sunflower meal | 2.50 | 2.50 | 2.50 |
| Citrus pulp | 0.00 | 8.85 | 10.50 |
| Meat meal | 1.50 | 2.00 | 2.00 |
| $CaSO_4$ | 0.00 | 0.15 | 0.00 |
| Sodium bicarbonate | 0.00 | 0.00 | 0.75 |
| Di-calcium phosphate | 0.12 | 0.18 | 0.25 |
| Mineral supplement | 0.45 | 0.45 | 0.45 |
| Vitamin supplement | 0.45 | 0.45 | 0.45 |
| NaCl | 0.30 | 0.25 | 0.40 |

Table 2. Calculated analysis of experimental rations offered to the dairy cows

| Composition | Phase of experiment | | |
|---|---|---|---|
| | Far-off | Close up | Lactation |
| DM (%) | 48.32 | 46.59 | 45.11 |
| NEl (Mcal/kg DM) | 1.35 | 1.65 | 1.72 |
| CP (% DM) | 12.60 | 15.60 | 17.30 |
| NDF (% DM) | 52.80 | 39.50 | 33.70 |
| FNDF (% DM) | 44.60 | 25.40 | 20.20 |
| ADF (% DM) | 34.10 | 24.00 | 20.90 |
| NFC (% DM) | 24.90 | 35.90 | 38.50 |
| Ca (% DM) | 0.96 | 1.00 | 1.02 |
| P (% DM) | 0.38 | 0.48 | 0.49 |
| Mg (% DM) | 0.31 | 0.42 | 0.28 |
| K (% DM) | 1.36 | 1.19 | 1.16 |
| Na (% DM) | 0.19 | 0.17 | 0.40 |
| Cl (% DM) | 0.55 | 0.41 | 0.43 |
| S (% DM) | 0.27 | 0.28 | 0.22 |
| DCAD (mEq/kg DM) | 104 | 88 | 215 |

Daily DMI was measured from 60 d prepartum to 42 d postpartum. Cows were milked every 8 h daily and milk production was recorded at the end of each week of lactation. Weekly milk production was derived from individual cow milk yield (kg) recorded at each milking. Milk fat and protein concentrations were determined in successive evening and morning samples of milk each week.

*Statistical analysis:* The following model was used in this experiment:

$$Y_{ij} = \mu + x_i + cov + \varepsilon_{ij}$$

where $Y_{ij}$, any observation; $\mu$, total mean; $X_i$, treatment effect; cov, data covariance, and $\varepsilon_{ij}$, effects of experiments error.

The model used to analyze the dry matter intake, milk production and composition, included the effects of close-up period length, use of lasalocid, and the interaction of close-up period length and lasalocid usage.

The effects of shortening close-up period length associated with lasalocid, on dry matter intake, milk production, and milk fat and protein percentage as well as FCR were determined using Proc Mixed of SAS (2006).

## RESULTS AND DISCUSSION

*Dry matter intake* (*DMI*)*:* Prepartum DMI was not significantly affected by the treatments (Table 3). At calving day, close-up period length, lasalocid administration, and close-up length × lasalocid administration interaction had no significant effects on DMI (Table 3). But shortening of the close-up period resulted in improved postpartum DMI significantly (Table 3). Finally, close-up period length, lasalocid administration, and close-up length × lasalocid administration, had significant effects on postpartum DMI as kg/d or % BW. The higher DMI (%BW) was related to (10+L) group while as kg/d was for 10+L and 10-L groups.

The DMI of cows in many experiments declined in the 3 weeks preceding parturition (Janovick and Drackley 2010, Huang *et al.* 2014, Amirabadi Farahani *et al.* 2017). In our

Table 3. Effects of close-up period length and lasalocid supplementation on dairy cows dry matter intake and lactation parameters

| Item | Treatments | | | | SEM | P value | | |
|---|---|---|---|---|---|---|---|---|
| | Control (n=12) | 21+L (n=12) | 10-L (n=12) | 10+L (n=12) | | Close-up period length | Lasalocid | Close-up period length × Lasalocid |
| Prepartum DMI (kg/d) | 10.73 | 10.86 | 10.94 | 11.40 | 0.2870 | 0.2337 | 0.3462 | 0.5826 |
| Parturition day DMI (kg/d) | 10.60 | 10.45 | 10.50 | 10.61 | 0.1363 | 0.7893 | 0.8841 | 0.3456 |
| Postpartum DMI (kg/d) | $15.72^{b}$ | $16.07^{b}$ | $16.20^{a}$ | $18.12^{a}$ | 0.3493 | 0.0019 | 0.0044 | 0.0373 |
| Prepartum DMI (%BW) | 1.63 | 1.82 | 1.79 | 1.86 | 0.0354 | 0.3267 | 0.4078 | 0.4889 |
| Postpartum DMI (%BW) | $2.53^{c}$ | $2.64^{b}$ | $2.63^{b}$ | $2.90^{a}$ | 0.0337 | 0.0001 | 0.0023 | 0.0278 |
| Mean milk yield (kg/d) | $33.3^{c}$ | $36.1^{b}$ | $32.2^{c}$ | $39.8^{a}$ | 0.5125 | 0.0166 | <0.0001 | <0.0001 |
| 4% FCM (kg/d) | $33.1^{b}$ | $35.5^{a}$ | $33.7^{b}$ | $36.5^{a}$ | 0.5214 | 0.1086 | <0.0001 | 0.6611 |
| Milk fat (%) | $3.67^{b}$ | $3.60^{b}$ | $3.92^{a}$ | $3.24^{c}$ | 0.0573 | 0.4039 | <0.0001 | <0.0001 |
| Milk protein (%) | $2.72^{b}$ | $2.88^{a}$ | $2.89^{a}$ | $2.59^{b}$ | 0.0548 | 0.3251 | 0.2059 | 0.0001 |
| FCR (kg Feed/kg Milk) | $0.471^{a}$ | $0.443^{b}$ | $0.503^{a}$ | $0.454^{b}$ | 0.0472 | 0.0389 | 0.0586 | 0.0427 |

*Means on the same row with different superscripts differ significantly (P<0.05). **Control (21-L), cows had 21 days close-up period without lasalocid; 21+L, cows had 21 day close-up period supplemented with lasalocid; 10-L, cows had shortened (10 days) close-up period without lasalocid; 10+L, cows had shortened close-up period (10 days) supplemented with lasalocid.

experiment, DMI decreased near calving, but increased after calving, especially in 10-L and 10+L groups. Our results were in line with findings of Huang *et al.* (2014) who reported that lowering prepartum energy density leads to lower energy intake in prepartum and more DMI postpartum in multiparous dairy cows. Amirabadi *et al.* (2017) found that postpartum milk yield was not affected by the length of close-up period.

Nutritional strategies should promote vigorous appetites after parturition that results in rapid increases of DMI postpartum (Douglas *et al.* 2006). About one-half of multiparous dairy cows experience moderate to severe fatty liver at calving (Grummer 1995) and this is because that near calving, dairy cows have low appetite and therefore it is must to promote cows appetite in this period.

In our experiment, shortening the close-up period length was the main strategy for promoting the DMI after calving. As mentioned above, close-up period length had significant effect on DMI postpartum. This is because that, cows in 10-L and 10+L groups had more appetite after calving. Shorter close-up period length, conduce to more appetite near and after calving and more DMI postpartum. Among 10-L and 10+L, cows in 10+L groups, had more appetite and more glucose availability after lasalocid usage, and therefore had lower adipose mobilization. If we prepare required feed for transition cows, we can decrease fatty liver incidence. In our study, cows of 10-L and 10+L groups had more appetite and more DMI than other 2 groups.

One of the important reasons of lower DMI in control and 21+L is ratio of concentrate to forage before calving. Coppock *et al*. (1972) indicated that use of more ratio of concentrate to forage, leads to lower dry matter intake after calving. In this experiment, since these 2 groups (especially control cows) consumed transition rations for longer time (21 d), they had lower appetite and lower DMI postpartum. Cows in 10+L group, during all of experimental weeks, had highest dry matter intake (especially in last weeks of experiment; Table 3). Roche *et al.* (2007) indicated that high concentrate feeding, can decline postpartum blood ghrelin and this conduce to lower feed intake after calving. Therefore cows in 10-L and 10+L groups, that consumed lower concentrate pre calving, will have more DMI postpartum.

The DMI of individual cows was significantly affected by shortening the close-up period. The DMI level is associated with appetite level. One of the most important affecting factors in DMI level is leptin, which controls appetite of cows and is called satiety hormone; adipose (fat tissue) is its secretion site. It appears that energy balance is one of responsible factors for the regulation of the plasma leptin in postparturient dairy cows, since non-lactating cows in positive energy balance had a higher leptin concentration than lactating cows in negative balance (Block *et al.* 2001). In dry Holstein cows, the leptin concentration in plasma was related to body fatness as determined by adipocyte size (Chilliard *et al.* 2001). Block *et al.* (2001) found that leptin correlated significantly to insulin, NEFA, growth hormone, and glucose in postpartum cows with both positive and negative energy balance.

Cows in 10-L and 10+L groups having shorter close-up period, had lower fat deposit and consequently lower leptin made site. Therefore, these cows probably had more appetite near and after calving and then consume more DMI (Table 3). Grant and Albright (1995) indicated that in prepartum period (7 to 5 d prepartum), approximately 30% decline in DMI was observed, and immediately after calving till 21 d postpartuma rapid increase in DMI was observed. In this experiment, cows in 10+L group, had more DMI than another groups of cows prepartum (no significant) and postpartum (significant). Increasing DMI especially in postpartum is one of our desirable findings. Another reason of increasing DMI in 10+L could be the lower left displaced abomasum (LDA) incidence. Using lower concentrate to forage ratio in close-up period, resulted in lower incidence of LDA near calving and early lactation and could conduce to more DMI.

Litherland *et al.* (2012) indicated that forage source and amount of DM fed prepartum affected postpartum performance and milk production. In current experiment, wheat straw was used as a controller of energy in dry cows and cows that consumed wheat straw for longer time (i.e. 10+L and 10-L treatments), had more DMI postpartum. More DMI in 10-L and 10+L treatments, conduce to lower metabolic disorders incidence such as left displaced abomasums (LDA), ketosis and fatty liver in early lactation. Eighty to 90% of LDA are diagnosed within 1 month postpartum (Shaver 1997). Therefore with increase in feed intake and DMI, LDA incidence will be lower. More forage in treatments of 10-L and 10+L for longer period in cows led to more rumen filling and subsequently lower LDA will occur.

*Milk production:* Mean milk production was significantly affected by close-up period length, lasalocid administration, as well as close-up length × lasalocid administration interaction. Cows assigned to treatment 10+L had significantly more milk production than other cows (Table 3). The lower milk yield was in control group and 10-L treatment.

Energy intake is a primary limitation on milk yield for high producing dairy cows and is determined by net energy content of the diet and DMI. Limiting the energy of 10-L and 10+L groups in close-up period led to higher appetite and more DMI in these groups after calving. For maximum milk production in fresh cows, excess or low feeding density should be avoided during entire dry period. Huang *et al.* (2014) reported that low energy in prepartum diet leads to increased postpartum milk yield in multiparous dairy cows.

Cows in 10+L groups had more milk production than other treatments. These cows compared to 21+L cows had significantly more milk production. Therefore improvement of milk production in 10+L can be attributed to close-up period length. Use of lasalocid in this experiment, had significant effect on milk production, but its effects was lower than close-up period length. Although, Amirabadi *et al.* (2017) indicated that shortening the close-up period could not affect milk yield; but in our study, shortening the close-up period, significantly improved milk production. One of the most important reasons of increase in milk yield in 10+L group in this study is the increase in DMI. More dry matter intake conduces to more milk production. Use of Lasalocid as a glucose producer can also increase milk synthesis, and lower negative energy balance. Lower negative energy balance after parturition, can result in lower metabolic disorders incidence. Another important reason of increase in milk production in 10+L group, is the use of lasalocid. Use of lasalocid in this study, had significant effect on milk production and improved milk yields in 10+L group and the same result, was obtained by Ignacio and Clark (2003) with monensin. They noted that improved energy balance after the use of ionophores leads to increase in milk production. Therefore, improvement in feed efficiency, can cause more milk production. In our study, desirable effects of lasalocid were related to energy availability for cows. Administration of lasalocid, conduce to lower milk fat production and led to lower negative energy balance and finally, energy availability for more milk production.

Our results are similar to those of Janovick and Darckley (2010); elevated DMI were found associated with increased milk production. These researchers demonstrated that prepartum energy intake during dry period conduce to an increase in milk production. Therefore energy controlling during prepartum period (especially in close-up period), can affect postpartum performance and milk production. They have also stated that the effects of energy controlling prepartum, is more effective in multiparous cows than primiparous cows. In our experiment, we have used multiparous Holstein cows and obtained similar results. Therefore cows in control and 21+L group that had lower DMI postpartum, had more risk factors for metabolic disorders and thus, lower milk yields of control cows attributed to lower DMI and more metabolic disorders.

*Milk composition:* Milk fat percentage was significantly affected by lasalocid administration and close-up length × lasalocid administration (Table 3). According to the results, close-up period length, did not significantly affect milk fat percentage, while lasalocid administration had significant effects on milk fat percentage. The higher and lower milk fat content was in 10-L and 10+L groups, respectively.

Milk protein percentage was significantly affected only by the close-up length × lasalocid administration (Table 3). Control group and 10+L had lower milk protein content than other treatments. In this study, milk fat percentage was significantly affected by lasalocid administration and close-up length × lasalocid administration but not by close-up length. The most important proposed reasons of decreasing milk fat percentage in 10+L group could be use of lasalocid has a decreasing effect on milk fat; more milk production of cows of 10+L group, conduce to lower milk fat, because when milk yield increase, its fat concentration will be decreased; decreasing the milk fat percentage after use of lasalocid caused by more availability of energy for milk production and consequently, milk production will be increased and lower NEB will be observed.

One of the most desirable aftermaths of decline of milk fat is lower negative energy balance. As mentioned above, cows in 10+L group had more DMI postpartum and this conduces to more milk production. Use of lasalocid in this experiment had a significant effect on milk fat percentage (Table 3), because lasalocid can decrease acetate production in rumen and because that milk fat synthesis is dependent to acetate availability, consequently this conduce to lower milk fat synthesis. Lower milk fat synthesis may be resulted in higher milk production as well as lower negative energy balance which in turn is conduce to lower incidence of some related metabolic disorders such as ketosis. However, fat lowering effects of lasalocid had not supported by Akins *et al.* (2014). Based on findings of Baumgard *et al.* (2002), it can be hypothesized that, reducing milk fat synthesis in our study, may allow for energy partitioning supporting increased milk synthesis. Huang *et al.* (2014) stated that feeding diet containing high energy density prepartum resulted in higher milk fat content and lower milk lactose content during the first 3 week of lactation. Thus low energy content prepartum may lower milk fat content and improve milk yield.

*Feed conversion ratio (FCR):* Feed conversion ratio significantly affected by lasalocid administration and close-up length × lasalocid administration (Table 3). Supplementing lasalocid in close-up diets in both 21 days and 10 days period lengths led to better FCR in the tested cows.

Some of the practical factors that may affect feed efficiency of dairy cows are the level of milk production, type of diet, body size, changes in body tissue mass during lactation, environmental conditions, exercise, age at first calving, and productive lifespan. Among the mentioned factors, level of milk production, is one of the most important factors, and higher milk production is associated with more efficient partitioning of feed nutrients (Hutjens 2005).

Cows in 21+L and 10+L groups had better feed conversion ratio than other 2 groups. Therefore cows in these groups had better use of feed for conversion to milk and they are more profitable for dairymen and this is one of the most important economical findings of this experiment. Use of lasalocid in these treatments groups conduce to better feed conversion ratio. Among 21+L and 10+L groups, profitability was more in 10+L group, because these cows consume high fiber diets for longer time and higher energy diets (close-up rations) for shorter period and consequently, had lower input (feed) and more output (milk). Feed conversion ratio of cows in 10+L group was better than other treatments and one of the most important reasons of this event, is use of lasalocid. This is because lasalocid administration in 21+L and 10+L conduce to better feed conversion ratio than control and 10-L. Shortening the close-up period had no effect on feed conversion ratio, because cows in 21+L treatments (no shortening close-up period), had better feed conversion ratio than cows in 10+L.

Based on the results of the current research, shortening of close-up period (10 days instead of 21 days) with or without using lasalocid resulted in increasing postpartum dry matter intake. Shortening of close-up period associated with using lasalocid led to higher milk yield, and lower milk fat and protein content.

## ACKNOWLEDGEMENTS

The authors are grateful for valuable assistance and support of Magsal Dairy Farm, Qazvin, Iran, as well as Islamic Azad University, Shabestar Branch, Shabestar, Iran.

## REFERENCES

Akins M S, Perfield K L, Green H B, Bertics S J and Shaver R D. 2014. Effect of monensin in lactating dairy cow diet at 2 starch concentrations. *Journal of Dairy Science* **97**: 917–29.

Amirabadi Farahani T, Amanlou H and Kazemi-Bonchenari M. 2017. Effects of shortening the close-up period length coupled with increased supply of metabolizable protein on performance and metabolic status of multiparous Holstein cows. *Journal of Dairy Science* **100**: 6199–217.

Amirabadi Farahani T, Amanlou H, Farsuni N E and Kazemi-Bonchenari M. 2018. Interactions of protein levels fed to Holstein cows pre- and postpartum on productive and metabolic responses. *Journal of Dairy Science* **100**(8): 6199–6217.

Azzaz H H, Murad H A and Morsy T A. 2015. Utility of ionophores for ruminant animals: a review. *Asian Journal of Animal Sciences* **9**: 254–65.

Baumgard L H, Moore C E and Bauman D E. 2002. *Potential Application of Conjugated Linoleic Acid in Nutrient Partitioning*. Proceeding of Southwest Nutrition Conference, USA. pp 127–41.

Block S S, Butler W R, Ehrhardt R R A, Bell A W, Van Amburgh M E and Boisclair Y R. 2001. Decreased concentration of plasma leptin in periparturient dairy cows is caused by negative energy balance. *Journal of Endocrinology* **171**: 339–48.

Chilliard Y, Bonnet M, Delavaud C, Faulconnier Y, Lerou C, Djiane J and Bocquier F. 2001. Leptin in ruminants, gene expression in adipose tissue and mammary gland, and regulation of plasma concentration. *Domestic Animal Endocrinology* **21**: 271–95.

Coppock C E, Noller C H, Wolfe S A, Wolfe S A, Callhan C J and Baker J S. 1972. Effect of forage-concentrate ratio in complete feeds fed *ad libitum* on feed intake prepartum and the occurrence of abomasal displacement in dairy cows. *Journal of Dairy Science* **55**: 783–89.

Douglas G N, Overton T R, Bateman H G, Dann H M and Drackley J K. 2006. Prepartal plane of nutrition, regardless of dietary energy source, affects periparturient metabolism and dry matter intake in Holstein cows. *Journal of Dairy Science* **89**: 2141–57.

Grant R J and Albright J L. 1995. Feeding behaviour and management factors during the transition period in dairy cattle. *Journal of Animal Science* **73**: 2791–803.

Grummer R R. 1995. Impact of changes in organic nutrient metabolism on feeding the transition dairy cow. *Journal of Animal Science* **73**: 2820–33.

Hayirli A, Grummer R R, Nordheim E V and Crump P M. 2002. Animal and dietary factors affecting feed intake during the pre-fresh transition periods in Holsteins. *Journal of Dairy Science* **85**: 3430–43.

Huang W, Tian Y, Wang Y J, Simayi A, Yasheng A, Wu Z, Li S and Cao Z. 2014. Effect of reduced energy density of close-up diets on dry matter intake, lactation performance and energy balance in multiparous Holstein cows. *Journal of Animal Science and Biotechnology* **5**: 30.

Hutjens M F. 2005. Dairy efficiency and dry matter intake. Proceedings of the '7th Western Dairy Management Conference'. March 9–11, Reno, NV, USA. pp 71–76.

Ignacio R I and Clark J H. 2003. Usefulness of ionophores for lactating dairy cows: a review. *Animal Feed Science and Technology* **106**: 39–57.

Janovick N A and Drackley J K. 2010. Prepartum dietary management of energy intake affects postpartum intake and lactation performance by primiparous and multiparous Holstein cows. *Journal of Dairy Science* **93**: 3086–102.

Janovick N A, Boisclair Y R and Drackley J K. 2011. Prepartum dietary energy intake affects metabolism and health during the periparturient period in primiparous and multiparous Holstein cows. *Journal of Dairy Science* **94**: 1385–400.

Litherland N B, Weich W D, Phasen W and Linn J G. 2012. Effects of feeding wheat straw or orchad grass at *ad libitum* or restricted intake during the dry period on postpartum performance and lipid metabolism. *Journal of Dairy Science* **95**: 7236–47.

McArt J A A, Nydam D V and Oetzel G R. 2013. Dry period and parturient predictors of early lactation hyperketonemia in dairy cattle. *Journal of Dairy Science* **96**: 198–209.

NRC. 2001. *Nutrient Requirements of Dairy Cattle*. Seventh revised ed. National Academy Press, Washington, DC.

Roche J R, Sheahan A J, Chagas L M and Berry D P. 2007. Concentration supplementation reduces postprandial plasma ghrelin in grazing dairy cows: A possible neuroendocrine basis for reduced pasture intake in supplemental cows. *Journal of Dairy Science* **90**: 1354–63.

SAS. 2006. *SAS Institute User guide: Statistics.* Version 9.1. SAS Inst. Inc., Cary, NC.

Shaver R D. 1997. Nutritional risk factors in the etiology of left displaced abomasums in dairy cows. A Review. *Journal of Animal Science* **80**: 2449–53.