Tropical and Subtropical Agroecosystems, 17 (2014): 155 - 159

Invited review

THE USE OF DIETARY FATS AND CONCENTRATES TO ALLEVIATE THE NEGATIVE ENERGY BALANCE IN CROSSBRED COWS IN EARLY LACTATION

[EL USO DE GRASAS Y CONCENTRADOS PARA CONTRARRESTAR EL BALANCE ENERGÉTICO NEGATIVO EN VACAS CRUZADAS EN LA LACTANCIA TEMPRANA]

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SUMMARY

Energy balance (EB) is defined as the difference between energy intake and energy expenditure. Fertility in the high-merit cow has been adversely associated with high milk production, low intake of energy and mobilisation of body reserves in early lactation, which combine in the term negative energy balance (NEB). The timing of insemination usually coincides with peak milk yield, when dairy cows are often in NEB. Crossbred cows (*Bos taurus* x *Bos indicus*) in the tropics have comparatively lower nutrient requirements and different partition of nutrients than high merit dairy cows. Thus, it would be expected that both the magnitude and length of negative energy balance were different in a crossbred cow. Because of marked differences compared with high-merit cows, crossbred cows in the tropics would be expected to show greater response to additional energy in early lactation improving their energy status and hence reproductive performance. Knowing the influence of nutrition on reproduction, many methods have been proposed for manipulating the diet to avoid or to alleviate negative energy balance. The use of fats is one alternative, which has been extensively studied in dairy and beef cows but with inconclusive results. Another alternative is to use starch-based concentrates, taking into account level of inclusion and quality and availability of pasture, in order to avoid substitution effects and to get maximum profits. Two experiments were carried out in Yucatan Mexico, in order to evaluate the use of bypass fats (calcium soaps of long-chain fatty acids, CAFA) or a starch-based concentrate to alleviate the NEB in grazing crossbred cows in early lactation. The NEB in early lactation was successfully avoided by the use of the starch-based concentrate but not by the use of bypass fats, this due to a reduction in the grass DM intake. It was concluded that crossbred cows in the tropics may experience a period of NEB postpartum, which can be avoided if they are supplemented with starch-based concentrates but not with bypass fats.

Keywords: Energy balance; dietary fats; concentrate; crossbred cows; early lactation.

RESUMEN

El balance energético (BE) se define como la diferencia entre el consumo y el gasto de energía. En vacas lecheras de alto mérito genético, la fertilidad se asocia negativamente con la alta producción de leche, el bajo consumo de energía y la movilización de reservas corporales en la lactancia temprana, todo lo cual se combina en el término *Balance Energético Negativo* (BEN). El momento de la inseminación o apareamiento de la vaca generalmente coincide con el pico de producción de leche, cuando éstas se encuentran a menudo en BEN. Las vacas cruzadas (*Bos taurus* x *Bos indicus*) en los trópicos tienen comparativamente menores requerimientos de nutrientes y diferente partición de nutrientes que las vacas lecheras de alto mérito genético. Por tanto, se esperaría que tanto la magnitud como la duración del BEN sea diferente en una vaca cruzada. Debido a sus marcadas diferencias con las vacas de alto mérito genético, se esperaría una mayor respuesta en vacas cruzadas al suministro adicional de energía durante la lactación temprana, reflejándose en mejoras en el status energético y por lo tanto, en el comportamiento reproductivo. Conociendo la influencia de la nutrición sobre la reproducción de la vaca, se han propuesto varios métodos para manipular la dieta con el fin de evitar o aliviar el BEN. El uso de grasas en la dieta es una alternativa que ha sido extensamente estudiada en vacas de leche o de carne, pero con resultados no concluyentes. Otra alternativa es el uso de concentrados a base de almidones, teniendo en cuenta sus niveles de inclusión, así como la calidad y disponibilidad de las pasturas, para evitar efectos de sustitución y para lograr los máximos beneficios. Se realizaron dos experimentos en el Estado de Yucatán, México, con el fin de evaluar el uso de grasas de sobrepaso (jabones de calcio de ácidos grasos de cadena larga, CAFA) o de un concentrado a base de almidones, para aliviar el BEN en vacas cruzadas en pastoreo, durante la lactancia temprana. El BEN fue exitosamente evitado por el uso del concentrado a base de almidones pero no por el uso de grasas de sobrepaso, esto debido a una reducción en el consumo de pasto. Se concluyó que las vacas cruzadas en los trópicos pueden sufrir un periodo de BEN postparto, el cual puede ser evitado con la suplementación con concentrados a base de almidones, pero no con el uso de grasas de sobrepaso.

Palabras clave: Balance energético; grasas; concentrado; vacas cruzadas; lactación temprana.

INTRODUCTION

In lactating dairy cows, it is difficult to interpret specific dietary intake effects on reproduction because they are confounded by level of milk production. Consequently, most authors now examine the relationships between energy in diet, milk output and body reserves, which is combined in the term “energy balance” (Diskin et al., 2003; Garnsworthy and Webb, 1999).

Energy balance (EB) is defined as the difference between energy intake and energy expenditure. Energy intake is the amount of energy that the cow can extract from food and will vary with the type of food eaten and the appetite of the cow. Energy expenditure is the sum of energy required for maintenance, exercise and milk secretion. In the short term, the cow has the ability to compensate for negative or positive energy balances by either mobilising or depositing body energy reserves (Garnsworthy and Haresign, 1989).

In a typical lactation cycle of a dairy cow, milk yield increases after calving to a maximum between six and eight weeks into lactation. However voluntary food intake is low at calving and increases at a slower rate than milk yield, reaching a maximum several weeks after peak milk yield (Garnsworthy and Topps, 1982). This condition leads to the cow in a Negative Energy Balance (NEB) status during this period. Because of this delay between milk yield and food intake, mobilisation of body reserves takes place in an attempt by the cow to meet the high energy demands of lactation. In mid to late lactation, as milk yield decreases and appetite is high, partition of food energy moves away from milk production so that body reserves are replenished (Garnsworthy, 1988).

The timing of insemination usually coincides with peak milk yield, when dairy cows are often in NEB (Garnsworthy and Haresign, 1989). Severe NEB delays the onset of postpartum ovarian activity, because mammary function apparently has metabolic priority over reproductive functions (Beam and Butler, 1997; Lucy, 2003). Because individual cows respond to NEB by different combinations of increased feed intake and mobilization of body reserves, neither changes in body weight nor milk yield are as sensitive as energy balance in predicting the impact on days to ovulation (Butler and Smith, 1989).

High yielding cows have a greater capacity for intake and use of absorbed nutrients than low yielding cows and can only achieve their full productive potential through maximal nutrient intake. Maximum energy intake can be achieved by maximizing DMI and by increasing energy concentration of the diet by adding fat or by increasing the inclusion rate of high energy concentrates (Reynolds, Sutton and Beever, 2002).

Crossbred cows (*Bos taurus* x *Bos indicus*) in the tropics have comparatively lower nutrient requirements and different partition of nutrients than high merit dairy cows. Thus, it would be expected that both the magnitude and length of negative energy balance were different in a crossbred cow. Because of marked differences compared with high-merit cows, crossbred cows in the tropics would be expected to show greater response to additional energy in early lactation improving their energy status and hence reproductive performance.

Dietary Fats

Supplemental lipids have been used to increase the energy concentration of the diet and avoid negative associative effects sometimes experienced with cereal grains (Coppock and Wilks, 1991; Staples et al., 1998; Garnsworthy, 2002).

Many sources of supplemental fat have been fed to beef and dairy cattle under experimental conditions. These include blends of animal and vegetable fat, tallow, yellow grease, fishmeal, cottonseeds, soyabeans, rapeseeds, canola seeds, peanut hearts, safflower seeds, sunflower seeds, flaked fat, prilled fat, hydrogenated fat, calcium soaps of fat, medium-chain tryglicerides, and free fatty acids (Staples et al., 1998; Funston, 2004).

The fat content of “natural” diets for ruminants is less than 50 g/kg and ingestive problems can occur by

increasing total fat content of the diet to more than 100 g/kg (Garnsworthy, 2002).
Theoretically, supplementation of fat could have some of the following advantages:

- Increase the energy concentration of the diet because fat contains three times more net energy for lactation than protein- and carbohydrate-rich feeds (Palmquist, 1984)
- Improve the energetic efficiency because reduced loss of energy as heat, methane, and urine may be expected (Palmquist and Jenkins, 1980), and because the dietary fatty acids are incorporated directly into milk fat by the mammary gland (Wu and Huber, 1994; Garnsworthy, 2002)
- Reduce the risk of rumen acidosis and a decrease in milk fat percent induced by feeding high levels of cereal grains in the diet (Palmquist and Conrad, 1978; Palmquist, 1984).

Fats can be manipulated by several means in order to avoid adverse effects in the rumen and to retain availability in the small intestine (Palmquist, 1984). These modified fat products are known as “bypass fats” or “rumen inert fats”, and their protection against rumen microbial action can be natural (e.g. encapsulation in formaldehyde-treated casein or formation of calcium soaps) or physical (e.g. selection of fatty acids with a high melting point and small particle size) (Garnsworthy, 2002).

Development of commercial products based on calcium soaps of long-chain fatty acids (CaFA) offers dairy cattle producers a method of increasing energy concentration of rations without disturbing rumen fermentation (Palmquist, 1984; Chalupa et al., 1986; Espinoza et al., 1995).

Fat supplementation is a common practice in dairy cattle production, especially in early postpartum, primarily to increase the energy density of the diet and to try to meet the energy demands of lactation. Associative positive and negative effects on reproduction have been reported (Grummer and Carroll, 1991; Fahey et al., 2002). Due to the extreme differences in DMI and level of milk production, research from dairy cows may not be directly applicable to beef cows (Funston, 2004). Nutritional alternatives to overcome NEB include use of fats treated to be inert in the rumen and to be effectively absorbed in the lower tract (bypass fats). Such fats include calcium soaps of fatty acids, which have been extensively studied in dairy (Staples and Thatcher, 2005) and beef cows (Funston, 2004), but not in the so called “dual-purpose” crossbred cows, which are predominant in the Latin American tropics.

Few studies of fat supplementation under grazing conditions include calculations of energy balance. An experiment was carried out in Yucatan, Mexico, using 24 Holstein x Zebu cows, in order to study the effects of a calcium soap of palm fatty acid (CaFA) supplement on energy balance, milk production and reproductive performance of grazing cows in early lactation (Aguilar-Pérez et al 2009a).

Mean milk yield over the first 98 days of lactation was not significantly different between diets. However the cows which received the fat supplement (*ByFat*) were more persistent than the control cows; the rate of decline in milk yield during the experiment was 21 g/day for control cows and 6 g/day for cows fed ByFat.

In this experiment, ByFat had no effect on reproductive performance due to a reduced grass DM intake, which resulted in no treatment difference in energy balance. It was concluded that supplementation with a calcium soap of long chain fatty acids is not effective for improving energy balance or reproductive performance in low-merit grazing cows in the tropics.

Starch-based concentrates

It is has been established that there is a curvilinear relationship between plane of nutrition (total energy supply) and both milk production and live weight change (Broster and Thomas, 1981). Also, increasing the plane of nutrition produced a greater milk production response (and smaller live-weight response) in cows of high than of low milk potential (Leaver, 1988). Cows of higher potential for milk production have greater voluntary intakes and partition proportionately more metabolic energy (ME) to milk and less to live weight than lower potential cows (Leaver, 1988; Chilliard, 1991).

In general, it is well known that concentrates can either improve or decrease grass matter intake, depending mainly on the allowance and quality of the pasture and amount and quality of the concentrate. Depending on the quality of the forage consumed, animals may substitute supplement for forage, there may be an additive effect, or there may be no change at all (Forbes, 1995; Minson, 1990).

Substitution rates of concentrates for forage in general fall between 0.33 and 0.67 (Leaver, 2002) and increase when concentrates constitute more than 25% of the diet (Dixon, 1986; Combellas, 1998) or more than 0.7 – 0.8% of body weight (Canton and Dhuyvetter, 1997).

In a second study, we designed an experiment to evaluate the role of supplementation with a cereal-based concentrate on energy balance, milk production and reproduction of grazing crossbred cows in early lactation (Aguilar-Pérez et al 2009b). There were used 48 Holstein x Zebu cows. The supplement consisted of sorghum (69%), soyabean meal (14%), wheat bran (15%) and minerals (2%), contained 878 g/kg dry matter (DM), 168 g/kg DM crude protein (CP) and 11.8 MJ/kg DM metabolisable energy (ME), and was offered at 30 % of estimated dry matter intake. A control group of cows was kept only on grazing. Supplementation increased intakes of DM, ME and CP, and increased milk yield by 30%.

Supplemented cows had a positive energy balance either on days 21 and 84 post-calving. It was concluded that grazing crossbred cows in the tropics may experience a period of NEB postpartum, which can be avoided using cereal-based concentrates, whilst improving milk production and reproductive performance.

CONCLUSION

It is concluded that grazing crossbred cows in the tropics can experience a period of NEB postpartum, which can be avoided if they are supplemented with starch-based concentrates but not with CaFA during early lactation.

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