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Review article

The role of nutritional supplementation on the outcome of superovulation in cattle

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ABSTRACT

Since the 1990s nutritional supplements including protein, fatty acids, vitamins, and minerals have been used to try and improve the superovulatory response of embryo donors in cattle. However, the accumulated information indicates that nutritional supplementation with protein, fatty acids, or minerals does not increase the number of viable embryos from superovulated cattle. Most of the evidence has shown that vitamin supplementation may increase the mean production of transferable embryos, but only in cows, as a detrimental effect on embryo viability has been reported in young heifers. Nevertheless, vitamin supplementation seems to be effective only when compared with control cows displaying a poor mean embryo production (i.e. less than four viable embryos), questioning the economical significance of such approach. Detrimental effects on embryo development have been reported in superovulated cattle supplemented with protein or fatty acids as well. New approaches to investigate the role of nutritional supplementation on superovulatory outcome in cattle are suggested in the present review. Overall, the available evidence indicates that nutritional supplementation strategies tested are not an effective approach to enhance the superovulatory outcome of well-fed cattle donors.

Contents

1. Introduction

Embryo production by superovulation in cattle has been used commercially since the 1970s (Mapletoft and Hasler, 2005) in multiple ovulation and embryo transfer (MOET) programs for the propagation of offspring of superior genetic merit cattle for beef and dairy production. Bovine models of superovulation are not only relevant for livestock production, but also for conservation biology and biomedical research (Velazquez, 2008; Velazquez et al., 2009). Although current bovine superovulatory programs are relatively well-established procedures (Bó et al.,

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Table 1
Effect of fatty acid supplementation on the superovulatory response of bovine embryo donors.

Type of donor	Fatty acid source (n)[a]	Variables of superovulatory response (mean ± S.E.M.)					Reference
		CL	O/E	VE	DE	UF	
Beef cows	WSB (20)	–	14.7 ± 3.0	10.3 ± 2.5	3.3 ± 1.1	1.1 ± 0.5	Bader et al. (2005)
	SBS (20)		17.5 ± 3.5	13.6 ± 2.6	1.6 ± 0.5	2.3 ± 1.2	
	P-value		0.55	0.38	0.20	0.31	
Dairy cows	SAT (6)	9.7 ± 2.0	4.3 ± 1.4	2.9 ± 1.0	–	–	Thangavelu et al. (2007)
	FLAX (7)	14.1 ± 2.5	5.6 ± 1.5	3.6 ± 1.1			
	SUN (7)	11.1 ± 2.6	7.0 ± 1.8	4.3 ± 1.4			
	P-value	0.41	0.50	0.27			
Beef heifers	n-3 PUFA(17)	15.0	8.8	5.8	1.2	1.6	Childs et al. (2008)
	SAT (16)	17.5	11.0	6.6	4.0	1.0	
	P-value (SED*)	>0.05 (2.3)	>0.05 (2.3)	>0.05 (1.6)	<0.05 (1.7)	>0.05 (0.6)	
Dairy cows	FLAX (13)	–	7.9 ± 1.1	3.1 ± 0.5	2.3 ± 0.4	2.5 ± 0.8	Petit et al. (2008)
	MEG (13)		7.3 ± 1.1	4.3 ± 0.5	1.3 ± 0.4	1.7 ± 0.8	
	P-value		>0.05	>0.05	>0.05	>0.05	

CL, corpora lutea; O/E, oocytes + embryos; VE, viable embryos; DE, Degenerated embryos; UF, unfertilized oocytes; WSB, whole soybean; SBS, soybean meal and soybean hull; SAT, saturated fatty acids, FLAX, whole flaxseed; SUN, sunflower seed; MEG, calcium salts of palm oil; – = not reported; *standard error of the difference;

[a] Treated animals in each experiment.

2008), the outcome of superovulation in cattle is affected by several factors (Kafi and McGowan, 1997; Velazquez, 2004; Mapletoft et al., 2006), including nutritional intake (Boland et al., 2001). The general consensus is that both energy deficits (e.g. negative energy balance [NEB] during early lactation) and overfeeding (e.g. non-lactating cows with high body condition score) exert a negative effect on the production of embryos with superovulated cattle donors (Sartori et al., 2007; Santos et al., 2008b). On the other hand, nutritional supplementation with protein, fatty acids, vitamins, or minerals has been used to try and improve the superovulatory response in cattle donors. However, although these nutritional elements are essential for mammalian reproduction (Smith and Akinbamijo, 2000; Hostetler et al., 2003; Wathes et al., 2007) and need to be included in the standard diet formulation, there is no clear evidence showing that nutritional supplementation can actually improve the superovulatory outcome in well-fed healthy embryo donors. This review will attempt to clarify the usefulness of nutritional supplements on the *in vivo* production of cattle embryos by superovulation.

2. Effects of fatty acid supplementation on superovulatory outcome

Fats and oils provide a source of fatty acids (FA) essential for numerous physiological processes, including reproduction (Wathes et al., 2007; Santos et al., 2008a). Fatty acids present in the ovarian follicles and oviductal–uterine tract serve as a source of energy for oocytes and preimplantation embryos respectively (McEvoy et al., 2000; Tsujii et al., 2001; Ferguson and Leese, 2006). Positive effects of fatty acid (FA) supplementation on reproductive function have been observed in non-superovulated cattle (reviewed in Mattos et al., 2000; Funston, 2004; Santos et al., 2008a). In contrast, early research found no effect of soybean oil (polyunsaturated FA) or animal tallow (saturated FA) supplementation on the superovulatory response of beef heifers (Ryan et al., 1992; Thomas and Williams, 1996). Similarly, more recent studies comparing different sources of FA in superovulated bovine donors have not shown any beneficial effect of FA supplementation on the *in vivo* ovarian follicular development (Cavalieri et al., 2005; Thangavelu et al., 2007) and production of viable embryos (Table 1). The lack of effect has been attributed to the presence of a dominant follicle at the time of FSH treatment, differences in FA intake, and energy status at the time of treatment (Ryan et al., 1992; Thomas and Williams, 1996; Bader et al., 2005). Interestingly, a negative effect of moderate fat supplementation (6%) on embryo quality has been reported in superovulated dairy cows (Coscioni et al., 2002). Likewise, dairy cows fed with whole flaxseed displayed a decrease in fertilization rate and an increase in embryo degeneration rate compared to cows treated with calcium salts of palm oil (Petit et al., 2008). The detrimental effect of FA supplementation in superovulated donors probably depends on several factors, including the type of FA used, and variables affecting superovulatory responses, such as breed, age, and environment (e.g. heat stress) (Lerner et al., 1986; Chagas e Silva et al., 2002; Krininger et al., 2003; Benyei et al., 2006). For instance, in Brazil (tropical environment), superovulated *Bos indicus* cows supplemented with Linseed produced more degenerated embryos than control cows (Albuquerque et al., 2007), whereas in Ireland (temperate environment) a reduction in the number of degenerated embryos was observed in *B. taurus* beef heifers supplemented with n-3 polyunsaturated FA (Childs et al., 2008). This contrasting effect of FA supplementation could also depend on the inherent lipid metabolism of donors. For example, oocyte lipid content is higher in *B. indicus* than in *B. taurus* cows (Ballard et al., 2008), and excessive oocyte lipid content has been associated with subfertility (Båge et al., 2007). Jersey cows are characterized by higher milk fat content compared with other dairy breeds such as Holstein cattle (Seidel, 2006), and may produce embryos of dark color (Hill and Kuehner, 1998), which is indicative of high lipid content (Abe et al., 2002; Leroy et al., 2005). Dark color embryos from Jersey donors