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Short-term supplementation with maize increases ovulation rate in goats when dietary metabolizable energy provides requirements for both maintenance and 1.5 times maintenance

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This study aimed to evaluate ovarian follicular dynamics in goats submitted to synchronization of estrus and supplemented with diets that differed in the metabolizable energy source and amount of energy. The experiment was carried out using 42 does allocated into three treatments, fed for 9 days with a ration providing 1.0 times maintenance containing maize (1 MM, n = 14) or without maize (1 M, n = 14) or a ration providing 1.5 times maintenance containing maize (1.5 MM, n = 14). Estrus was synchronized with two injections of cloprostenol given 7 days apart. Does were also treated with intravaginal progesterone inserts and eCG. The number of ovulations and size of the follicles were measured using ultrasonography on Days 10, 11, and 12 after the start of the dietary treatment. The interval to estrus and duration of estrus did not differ between treatments ($P = 0.382$). Does fed with 1 and 1.5 MM had a similar number of ovulations but a greater number of ovulations than goats fed with 1 M ($P = 0.028$). The mean number of small, medium, large, and total number of follicles on Days 10 to 12 of ultrasound evaluations did not differ ($P = 0.204$) between treatments, but mean numbers changed over time ($P < 0.001$). The mean frequency and amplitude of LH pulses and concentrations of glucose, insulin, leptin, and insulin growth factor-1 in plasma were not significantly affected ($P > 0.258$) by any of the treatments. In summary, the inclusion of maize in the ration can stimulate ovulation rate at maintenance level. Similar results between groups fed diets that included maize and provided metabolizable energy at 1.0 and 1.5 maintenance demonstrate that to increase the ovulation rate when synchronizing estrous cycles in does, dietary supplementation with maize can be restricted to provide a maintenance level of metabolizable energy only, which would reduce dietary costs.

1. Introduction

Nutrition exerts a significant influence on reproductive function through changes in body weight and body condition, affecting processes such as follicular development

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and ovulation rate [1–3]. Nutritional supplementation influences the selection of dominant follicles, increases follicular growth, and improves the quality of oocytes [4–6]. These changes in follicular development are enhanced through supplementation with high-energy and/or high-protein diets, as energy balance is a powerful regulator of reproductive function in ruminants [7].

There are limited data on the effect of a short-term supplementation with maize in goats on follicular development, ovulation rate, hormone, and metabolic profiles during supplementation. Several studies have shown that short-term nutritional supplementation for 4 to 11 days can promote an increase in ovulation rate in sheep [8–10]. In contrast, most studies have failed to demonstrate that short-term nutritional supplementation can increase ovulation rate but can cause an increase in the number of large follicles or the total number of follicles in sheep [11–14] and an increase in concentrations of glucose and insulin in goats [15]. Furthermore, a limited number of studies have evaluated the effect of supplementation with maize on ovarian function in sheep [14] and in goats [16,17].

Multiple hormones and metabolites appear to influence follicular development, for example FSH, LH, GH, glucose, insulin, leptin, and insulin growth factor-1 (IGF-1) [5,11]. Viñoles et al. [11] suggested that in ewes, the effect of 5 to 9 day nutritional supplementation on follicle development is not mediated by an increase in FSH concentrations but by increased concentrations of glucose, insulin, IGF-1, and leptin acting directly at the ovarian level to promote an increase in follicular steroidogenesis without affecting peripheral changes in serum concentrations of FSH. The results of other studies have also suggested that the stimulatory effects of short-term nutritional supplementation on folliculogenesis are mediated directly at an ovarian level with glucose, fatty acids, and several metabolic hormones having a direct action on the follicle [5,18]. These findings suggest that short-term nutritional supplementation that is likely to exert changes in metabolic hormones may exert changes in follicular development, which may confer production advantages if factors such as prolificacy can be influenced.

Previous studies have tried to address changes in ovarian function by changing the amount of energy provided in diets to experimental animals [11,15]. It has been shown that the efficiency of utilization of energy for maintenance increases when sheep and cattle are supplemented with maize [19]. However, there are no reports of the effects of changing the dietary ingredients that make up the metabolic energy requirement for maintenance as an alternative to increase follicular development. This method of changing the nutrient composition of the diet without changing the overall amount of metabolic energy could provide a novel method of influencing ovarian function in goats at a more modest cost compared with supplementing does above their maintenance requirements.

We hypothesized that goats supplemented with maize for 9 days, with diets designed to provide metabolizable energy at either maintenance or 1.5 times maintenance, will increase the concentrations of glucose and IGF-1 in plasma and increase the number of small and large follicles and ovulation rate, when compared with goats fed a diet that provides a maintenance level of metabolizable energy without the inclusion of maize. To confirm this hypothesis, this study aimed to evaluate the follicular dynamics and changes in LH, insulin, glucose, leptin, and IGF-1 in goats that were undergoing estrous cycles and supplemented with diets that differed in the amount of maize and the level of metabolizable energy provided.

2. Material and methods

2.1. Location, animals and evaluation period

The experiment was carried out at James Cook University, Townsville, Queensland, Australia (19°19′30″ S; 146°45′44″ E). The experiment was conducted between May and July, during the normal breeding season. A total of 42 nulliparous and nonpregnant does (21 Boer and 21 rangeland goats) were used in this study. At the start of the experiment, does aged 2.2 ± 0.1 years and had a live weight of 40.9 ± 1.0 kg (mean $\pm$ standard error of the mean [SEM]). All experimental procedures were approved by the Animal Ethic Committee of James Cook University (approval number: A1695).

2.2. Animal management and experimental design

The study was conducted in two blocks of 21 animals each, with seven animals allocated to one of three treatment groups in each block. A block was the period when homogeneous subgroups of animals were evaluated in the same design. Different individual animals were used in each block, but Boer and rangeland goats were evenly distributed within the blocks. The second block commenced on the day after the first block was completed.

Before commencement of treatments associated with each block, goats were adapted to individual pens in a building with natural light for 5 days. Does were supplemented daily with a base ration consisting of lucerne pellets and rhodes grass (*Chloris gayana*) hay, which provided nutritional requirements for maintenance (6.7 MJ ME/day) for a goat weighing 40 kg [20]. On Day 0 of the study, does were fed either 1.0 times maintenance without maize (1 M), 1.0 times maintenance with maize (1 MM), or 1.5 times maintenance with maize (1.5 MM); (Table 1). The maize and lucerne pellets were offered at 8 AM and Rhodes grass was offered at 5 PM. To ensure that cracked maize was all eaten in the groups fed maize, it was offered first and then lucerne pellets were offered about 15 minutes later. The feed intake of animals was monitored individually to confirm that the animals ate all the feed allocated each day. On Days 10 to 12, every doe was fed the maintenance diet that consisted of lucerne pellets and Rhodes grass hay only.

On Day 0, does were treated with an intravaginal progesterone releasing insert (CIDR, Eazi-Breed CIDR, Pfizer Australia, NSW), which was removed 9 days later (Fig. 1). In addition, does were treated with two injections of 125-μg cloprostenol IM (EstroPlan, Parnell, Australia) administered 7 days apart (Days −5 and 2) and 100 IU eCG IM (Equine chorionic gonadotropin; Folligon, Intervet, Australia) on Day 7 (Fig. 1).