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# Effect of grass dry matter intake and fat supplementation on progesterone metabolism in lactating dairy cows

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**Abstract**

Progesterone (P4) metabolism in dairy cattle can be manipulated by alterations in dry matter intake and diet composition. Our objectives were to determine the effects of grazing allowance and fat supplementation on P4 metabolism in lactating dairy cows. Forty mid- to late-lactation Holstein-Friesian dairy cows were used in a completely randomized block design, with a 2 × 2 factorial arrangement of treatments. Cows were assigned to receive 1 of 2 pasture allowances (ad libitum allowance [AL], 9.5 kg dry matter per day, or restricted allowance [R] 7 kg dry matter per day) and 1 of 2 fat supplementation treatments (750 g per day saturated fat [F] or no fat supplement [NF]). All cows received an additional 4 kg per day of concentrate. Grass dry matter intake (GDMI) was measured 5 wk after the initiation of dietary treatment. Cows were treated with prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) to eliminate the endogenous source of P4, and two intravaginal progesterone-releasing devices (CIDR) were inserted into each cow for a period of 8 days. Regular blood samples were taken before and after the removal of the intravaginal progesterone-releasing devices, and analyzed for P4 concentrations. The half-life (t½) and metabolic clearance rate (MCR) of P4 was calculated for each cow. There was no effect of GDMI or fat supplementation on the t½ or MCR of P4. There was a tendency for an interaction between GDMI and fat supplementation on the t½ of P4; cows on the restricted-F diet tended to have a longer P4 t½ than cows on the ad libitum-F diet. It was concluded that greater alterations in GDMI than achieved in the current study are required to change P4 metabolism. A combination of fat supplementation and restricted feeding slows P4 clearance, which may have beneficial implications for fertility.


*Keywords:* Progesterone metabolism; Dairy cattle; Fat supplementation; Dry matter intake

## 1. Introduction

Genetic selection programs during the past two decades have resulted in a modern dairy cow capable of producing large volumes of milk on high intake diets. The improvement has come at the expense of fertility and longevity, however, and the reproductive performance of dairy cows has been declining over the past 50 yr [1]. Embryo loss is the greatest factor contributing to reproductive inefficiency in dairy cows, with combined embryonic and fetal loss rates in high producing dairy cows averaging approximately 60% [2].

There is substantial evidence of a link between embryo survival and systemic concentrations of progesterone (P4) in both the cycle before ovulation and during the early luteal phase of the cycle after insemi-

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nation [2]. Positive linear and quadratic relationships have been identified between milk P4 concentrations on Days 4, 5, 6, and 7 after insemination, and also between the rate of change in P4 concentrations between Days 4 and 7 inclusive, and embryo survival [3,4]. Low circulating P4 concentrations around the time the developing blastocyst arrives in the uterine horn may affect the volume and/or composition of uterine secretions essential for embryo survival, rate of conceptus development, and the ability of the embryo to produce bovine interferon-tau (bIFN-$\tau$) [5].

Progesterone in blood is almost completely metabolized in a single pass through the liver [6]. Liver blood flow (LBF) and metabolic clearance rate (MCR) of P4 are elevated by increasing dry matter intake (DMI) in pigs [7], sheep [6], and dairy cattle [8,9]. Increased MCR of P4 reduces peripheral plasma P4 concentrations due to the inability of the corpus luteum to sufficiently increase its rate of P4 secretion to maintain homeostasis [6].

Fat supplementation has been shown to increase plasma P4 concentrations [10–12]. This has been hypothesized to be due to increased plasma cholesterol concentrations, the precursor essential for steroid synthesis [13]. This hypothesis has been questioned by Hawkins et al. [12], however, who observed that fat supplementation resulted in greater P4 half-life (t½) in circulation compared with control cows receiving no fat supplement. This indicates that reduced MCR is a major contributing factor to the increased plasma P4 concentrations in cows fed a high lipid diet.

Our objective was to determine the effects of herbage allowance and dietary fat supplementation on the t½ and clearance rate of plasma P4 in lactating dairy cows. We hypothesized that substituting a proportion of grass dry matter intake (GDMI) with supplementary fat would reduce the MCR of P4.

## 2. Materials and methods

### *2.1. Animals and treatments*

All experimental procedures involving animals were licensed by the Department of Health and Children, Ireland, in accordance with the Cruelty to Animals Act (Ireland 1876) and the European Community Directive 86/609/EC. Forty mid- to late-lactation (178 days in milk (DIM) ± 12 days SD) Holstein-Friesian cows were blocked on the basis of parity, calving date, body weight (BW) and body condition score (BCS), and randomly assigned to 1 of 2 pasture allowances (ad libitum allowance [AL], 9.5 kg dry matter [DM] per day, or restricted allowance [R], 7 kg DM per day) and 1 of 2 fat supplementation treatments (750 g per day saturated fat [F; Palmit 80; Trouw Nutrition, Belfast, UK], or no fat supplement [NF]). The experiment was a completely randomized block design with a 2 × 2 factorial arrangement of treatments. The fat supplements were mixed with 1.5 kg of a dairy concentrate and fed in individual feed troughs before morning milking. In addition to the 1.5 kg concentrate added to the fat supplement, fat-supplemented cows received an additional 2.5 kg per day of the same concentrate, offered in the parlor during milking. NF-supplemented cows received 4 kg per day of the same concentrate, offered in the parlor during milking. A 3-wk period of acclimatization to the treatments was allowed before any measurements were taken. The nutrient composition of the F and NF concentrates offered are presented in Table 1.

To manage the workload, animals were treated in groups of four cows per day, one cow from each treatment. Transrectal ultrasonography was carried out on all cows on Day 28 of dietary treatment in order determine the stage of the estrous cycle for each cow. On Day 34 (± 5 days) of dietary treatment, cows received 5 mL $PGF_{2\alpha}$ im (lutalyse; Pfizer Animal Health, Dublin, Ireland), followed by two similar injections at AM and PM milkings 11 days later to regress any corpus luteum present and eliminate endogenous P4 synthesis. Two intravaginal P4-releasing devices (Eazi-breed CIDR containing 1.38 g P4, Pfizer Animal Health) were

Table 1
Nutrient composition of the concentrated offered to fat-supplemented (F) and non fat-supplemented (NF) cows, and chemical composition of the grass offered.

| Nutrient composition (DM basis) | Concentrate | | Grass |
|---|---|---|---|
| | NF | F | |
| DM (g/kg) | 927.3 (0.81) | 927.5 (2.43) | 237.6 (28.59) |
| DM composition (g/kg of DM) | | | |
| CP (g/kg of DM) | 133.0 (16.60) | 104.3 (6.32) | 235.4 (39.13) |
| CF (g/kg of DM) | 80.7 (6.06) | 53.3 (2.07) | — |
| OMD | — | — | 795.3 (39.81) |
| NDF | — | — | 413.2 (41.72) |
| ADF | — | — | 247.5 (33.52) |
| Ash (g/kg of DM) | 93.8 (2.56) | 60.2 (3.60) | 160.5 (41.27) |
| Oil (acid hydrolysis; %) | 2.65 (0.37) | 31.6 (2.74) | — |

Values are the means of samples collected throughout the study, followed by the standard deviation of the mean in parenthesis.
ADF, acid-detergent fiber; CF, crude fiber; CP, crude protein; DM, dry matter; NDF, neutral-detergent fiber; OMD, digestibility of organic matter.