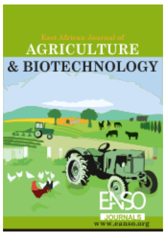

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Original Article

Influence of Feed Intake on Hormonal Profile of Post-parturient Friesian Cows in Uasin Gishu County – Kenya

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Feed Intake, Friesian Dairy Cows, Hormonal Profile, Post-Parturient Period.

ABSTRACT

The immediate post-parturient period of lactating cattle holds significant physiological and metabolic challenges arising from parturition and negative energy balance (NEB). The study examined the effect of feed intake on the hormonal profile of post-parturient Friesian cows in Uasin Gishu County, Kenya. Three farms, namely Elfam, Elso and Betan, from which nine Friesian cows whose milk production averaged 20 litres per day were selected. The study utilised a randomised complete block design (RCBD) and adopted a natural on–field experiment where nutritional diets in each farm were adopted. The cows were fed 40 kg of forage supplemented with minerals and water given ad libitum. The cows were weighed daily, and the feed intake was determined daily. Blood samples were collected a day after parturition and later in the morning at a 7-day interval and tested for cortisol, prolactin, oestrogen, and Insulin Growth Factor (IGF) levels. The data were entered into Microsoft Excel and Genstat 14 for descriptive and ANOVA analysis, and the results were presented in tabular and graphical formats. All cows had on average low feed intake at parturition and progressively increased the feed intake to 35 kg during the study period. Hormonal cortisol levels gradually declined while those of IGF, prolactin and oestrogen progressively increased during the 30-day study period. The study concluded that feed intake was significantly and positively correlated to prolactin (r = 0.760), Oestrogen (r = 0.785), and IGF-1 (r = 0.692) and negatively to cortisol (r = -0.613). Based on the results, the study concluded that there is a causal linkage between feed intake and the hormonal profile of post-parturient Friesian cows. The study recommends that commercial farmers should improve the nutritional requirements of dairy cows based on their physiological state.

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INTRODUCTION

The transition into lactation and the immediate post–parturient period is challenging for high-productive dairy cows due to the elevated demand in the energy, mineral and protein requirements (Sammad *et al.*, 2022) as the peri-parturient low DMI restricted the amounts of energy availability (Gross *et al.*, 2011). This dramatic surge in nutrient requirements following parturition is related to the demands of the mammary gland for the production of milk, milk fat, lactose and protein (Roche *et al.*, 2013). These wide-ranging metabolic and physiological changes in the early lactation period present an immediate challenge to dairy cows and subsequently influence the health status and performance of a lactating cow (Tanaka *et al.*, 2011).

Dairy cows in the peri-parturient period tend to decrease the dry matter intake (DMI) by between 10% to 30% (Drackley & Cardoso, 2014) a fact that is attributable to the foetal growth which reduces the abdominal cavity thus restricting the ruminal space (Chapinal *et al.*, 2012). Insufficient DMI into the early lactation period tends to lead to a deficiency in the amount of nutrients and energy resulting in Negative energy balance (NEB) (Bisinotto *et al.*, 2018). NEB is a metabolic change indicating the differences between energy uptake and energy requirements for a substantial physiological capacity of a lactating cow (Jorritsma *et al.*, 2013).

The thirty-day post–parturient period is characterized by elevated nutritional demands arising from the onset of lactation (Englyst *et al.*, 2007) and therefore optimizing the nutritional strategy during this time is imperative for milk productivity and feed intake (Englyst *et al.*, 2007). The dietary requirements in the lactation stages depend on the starch levels where the lower glucose availability significantly modifies the postprandial circulatory patterns of hormones (Piccioli-Cappelli *et al.*, 2014). These dietary changes interact with environmental changes leading to elevated cortisol levels which may negatively impact calcium metabolism, potentially contributing to hypocalcaemia (Wu *et al.*, 2019).

Hormone profiles of post-parturient dairy cattle have gained prominence as they significantly influence reproductive efficiency and milk production (Gaiani *et al.*, 2014). For instance, Sgorlon et al., (2015) demonstrated the linkages between elevated cortisol levels and decreased milk production, emphasizing the need for stress management strategies in dairy herd management (Sgorlon et al., 2015). Prolactin is linked to mammary gland development and initiation of lactation, cortisol is related to stress response and metabolism, while oestrogen is involved in reproductive functions, and Insulin-like Growth (IGF-1) contribute to growth and milk synthesis (Gaiani *et al.*, 2014).

Whereas a lactating cow may consume large quantities of starch, it still undergoes a negative energy balance in the immediate post-parturient period because of the increased milk production (Gross *et al.*, 2011). The competition for nutrients between early and late lactation periods tends to delay the animal's reproductive function (Kitilit *et al.*, 2016) as NEB predisposes lactating cows to metabolic disorders and may impair reproduction function, therefore the animal will most likely redirect the scarce nutrient resources in the early

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lactation period to milk production rather than to the next reproductive cycle (Drackley & Cardoso, 2014).

The endocrine-metabolic system determines the amount of milk produced depending on the lactation stage and is manifested by the hormone profiles and changes in the energy balance of a lactating cow (Piccioli-Cappelli *et al.,* 2014). As such the cow maintains its initial post-parturient lactational performance at the expense of a declined reproductive function (Toledo-Alvarado *et al.,* 2017). Thus, the negative nutrient balance compromises the reproductive performance as the quantity and composition of milk substantially affect the metabolic status of dairy cows (Bisinotto *et al.,* 2018; Piccione *et al.,* 2012).

There are specific individual cow differences on how they allocate energy to various functions and destinations. It is possible that cows with the same energy levels and similar milk production potential face different levels of actual NEB because they allocate lower energy requirements for fertility, maintenance, or immunity (Jorritsma *et al.,* 2013). Low-energy diets lead to an increase in the natural bovine somatotropin to insulin ratio which rapidly mobilizes lipid reserves resulting in a higher concentration of non-esterified fatty acids (NEFA) and β-hydroxybutyrate (βHBA) contributing to the higher butter fat content in milk (Piccioli-Cappelli *et al.,* 2014).

NEB is linked to the mobilization of body reserves, preferably the localized fat and muscle tissue because homeorhetic prioritization requires physiological demands of allocating nutrients to the mammary gland for milk production (Gross *et al.,* 2011). The characteristic changes in lipid metabolism lead to concurrent lipogenesis and lipolysis which subsequently supports synthesis of the lipid reserves which are utilized at parturition and the initiation of lactation. Furthermore, the hydrolysis of lipoprotein in triglycerides is influenced by the parturiency and post–parturiency period (Ayoub & Allam, 2015). Thus, when synthesis exceeds utilization, triacylglycerol (TAG) accumulates in the liver (Litherland *et al.,* 2011) a process that is indicated by the βHBA and the NEFA in the blood serum (Cincović *et al.,* 2012).

Low-energy diets result in significantly higher basal NEFA concentrations in early lactation periods (Piccioli-Cappelli *et al.,* 2014). Furthermore, excessive energy feed resources may result in higher NEFA and βHBA concentrations in blood and more TAG in the liver in the post–parturient period (Drackley & Cardoso, 2014). In the early lactation period, the NEFA concentration is always higher after the consumption of low-energy diets. However, the lactating stages do not influence the basal plasma glucose concentrations but in high-energy diets, the average daily glucose concentration is usually higher when compared to low-energy diets (Piccioli-Cappelli *et al.,* 2014).

NEB coupled with the metabolic changes concomitantly affect milk production and the health status of a lactating dairy cow when the energy requirements exceed the available energy from feed intake (Jorritsma *et al.,* 2013) as a metabolically - stressed cow in the early lactation period simultaneously experiences NEB with an elevated likelihood of health disorders (Gross *et al.,* 2011). The poor nutritional status is compounded with stress-related factors in the post–parturient period resulting in decreased voluntary DMI and concomitantly elevated TAG and NEFA concentrations. Whenever glucose supply is limited, there is an elevated likelihood of ketogenesis that may result in ketosis (Drackley & Cardoso, 2014).

The differences in NEB between lactating cows are a result of variations in feeding management rather than disparities in milk production. Thus, higher-yielding cows have an elevated likelihood of a profound NEB nadir (Jorritsma *et al.,* 2013). The post-parturient NEB is associated negatively with reproductive performance such that the degree of NEB nadir and the rate of change in NEB strongly indicates an impaired reproductive cycle (Ingvartsen & Moyes, 2013). This metabolic activity results in higher body weight loss during the early lactation period with slowed body

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weight recovery for lactating cows fed on low-starch diets (Djoković *et al.*, 2017).

Thus, adequate nutrition, proper herd management practices, and monitoring of physiological demands are essential to ensuring a smooth transition into post-parturiency and mitigating the likelihood of milk fever (Wu *et al.*, 2019) as dairy cows that successfully adapt to lactation can avoid metabolic or physiological imbalances and support both milk yield and reproductive performance while maintaining a healthy status (Drackley & Cardoso, 2014). In particular, dietary formulation for cows in the immediate post-parturient period is a critical aspect as it directly influences transition success and subsequent reproduction (Cardoso et al., 2020).

The immediate post-parturient period in dairy cows is characterized by significant hormonal and metabolic changes. Despite the awareness, there is a gap in understanding the comprehensive hormonal dynamics during this critical period and their specific implications for the cow's feed intake and milk production during the early days of post-parturiency. The abrupt physiological changes occurring during the peri- and post-parturient periods pose a substantial risk to the overall health status, milk yield, and reproductive functions of cows (Gaiani *et al.*, 2014). Thus, the study examined the physiological changes which include feed intake and hormone changes of Friesian cows at different parities during the first thirty–day post–parturient period in Uasin Gishu county, Kenya.

MATERIALS AND METHODS

The study was carried out in the Elfam, Elso and Betan farms in Uasin Gishu County which were purposively selected based on the following criteria; herd management practices, and owners' willingness to participate in the study. In each farm, three lactating Holstein Friesian cows were selected based on average milk production of 20 litres per day, averagely similar calving moment and post–parturient period but with different lactational cycles (parities) (2nd, 3rd and 4th parities). The study utilised a randomised complete block design which is usually used in experimental studies with parity being designated as a factor, while farm effects (feed formulation and herd management) were blocked. The selected cows were initially weighed at the start of the experimental period using the weight band and then weighed daily for the next thirty-day period. The study gave a 40 kg mixture of (silage, hay, Napier grass, concentration and/or substitute plant protein) as formulated by each farm once a day to the animal, and after a day, the feed leftovers were weighed and discarded, and new feed was introduced. Elfam used substitute plant-based supplementation and utilised Lucerne and Desmodium, while both Elfam and Betan farms utilised standard concentrate supplementation (Dairy Meal)

Data Collection and Analysis

Feed Sampling and Proximate Analysis

At the beginning, middle and close of the experiment, feed samples of 200 grams were collected from Elfam, Elso and Betan farms and air dried under shade for two days to effect uniform drying before being packaged in cotton paper bags and labelled accordingly. The samples were sent to the Kenya Agricultural Livestock Research Organization (KALRO, Naivasha) for feed analysis. These ground feed samples were subjected to proximate analysis for dry matter, crude protein, crude fibre, ash and fat (ether extracts) were determined by Association of Official Analytical Collaboration (AOAC) procedures (2019). Upon completion of the laboratory analysis, the data underwent a comprehensive quantitative analysis using GenStat 14.

The feed intake data from the different animals were recorded manually before being collated and entered into a Microsoft Excel worksheet. The data was analysed descriptively (mean and standard deviation) to determine the trends, which were presented in graphical format and then analysed inferentially using Analysis of Variance (ANOVA) and correlation statistics. The study determined the feed consumed using the

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following formula, and the data were recorded for the next 30 days.

Feed consumed = Feed given – feed left over.

Blood Sampling and Hormone Analysis

Blood samples were collected in labelled vacutainer tubes at parturition and thereafter, after the 7th-day interval between 7:00 AM and 8:00 AM for the study period. The blood sample was drawn aseptically from the jugular vein into a 7cc vacutainer tube before being transferred and stored in a cooler box at 2 - 8 ºC and delivered to the analytical laboratory within 2 hours. The blood samples were kept in a 45^0 tilt to allow the serum to settle in a refrigerator at temperatures ranging between 0 – 4 ºC, awaiting the determination of the respective hormones. The hormonal tests: Cortisol Check-1 test for cortisol hormone, the Prolactin-Check-1 test for prolactin hormone, the Enzyme-Linked Fluorescent Assay (ELFA) test for Oestrogen hormone and radioimmunoassay (RIA) test for the IGF-1 hormone at the Nairobi Annex Laboratory, Eldoret. All the procedures were based on VEDA-LAB instrumentation, and the outputs were compared using descriptive statistics (means and standard deviation) and F–test.

Data Analysis

The randomised complete block design (RCBD) is a standard design for conducting agricultural scientific experiments where similar experimental units are grouped into blocks or replicates and are used to control variation in an experiment by accounting for spatial effects in the field as shown in Table 1 below.

Table 1: Study Design

Source of variation (SOV)	Degrees of Freedom (DF)	Sum of Squares (SS)	Mean sum of squares (MS)	Fcal
Treatment (t)	t-1 = 4	SS treat	SS treat/t-1	MST/MSE
Block (r)	r-1 = 2	SS block	SS block/ r-1	MS block/ MSE
Error	(t-1)(r-1) = 8	SS error	SS error/(t-1)(r-1)	
Total	(tr-1) = 14	SS total		

RESULTS AND DISCUSSION

Weight Performance of the Dairy Cattle during the Post-parturient Period

The average growth of the Friesian cows at each parity is presented in a graphical illustration in Figure 1. The dairy cows in parity 4 had the highest average weight with a minimum of 640 kg and were significantly ($p < 0.05$) heavier than the dairy cows in parity 3 and parity 2. The cows in parity 3 had a comparatively average minimum weight of 564 kg but were not significantly different ($p > 0.05$) from the cows in parity 2, which weighed 537 kg.

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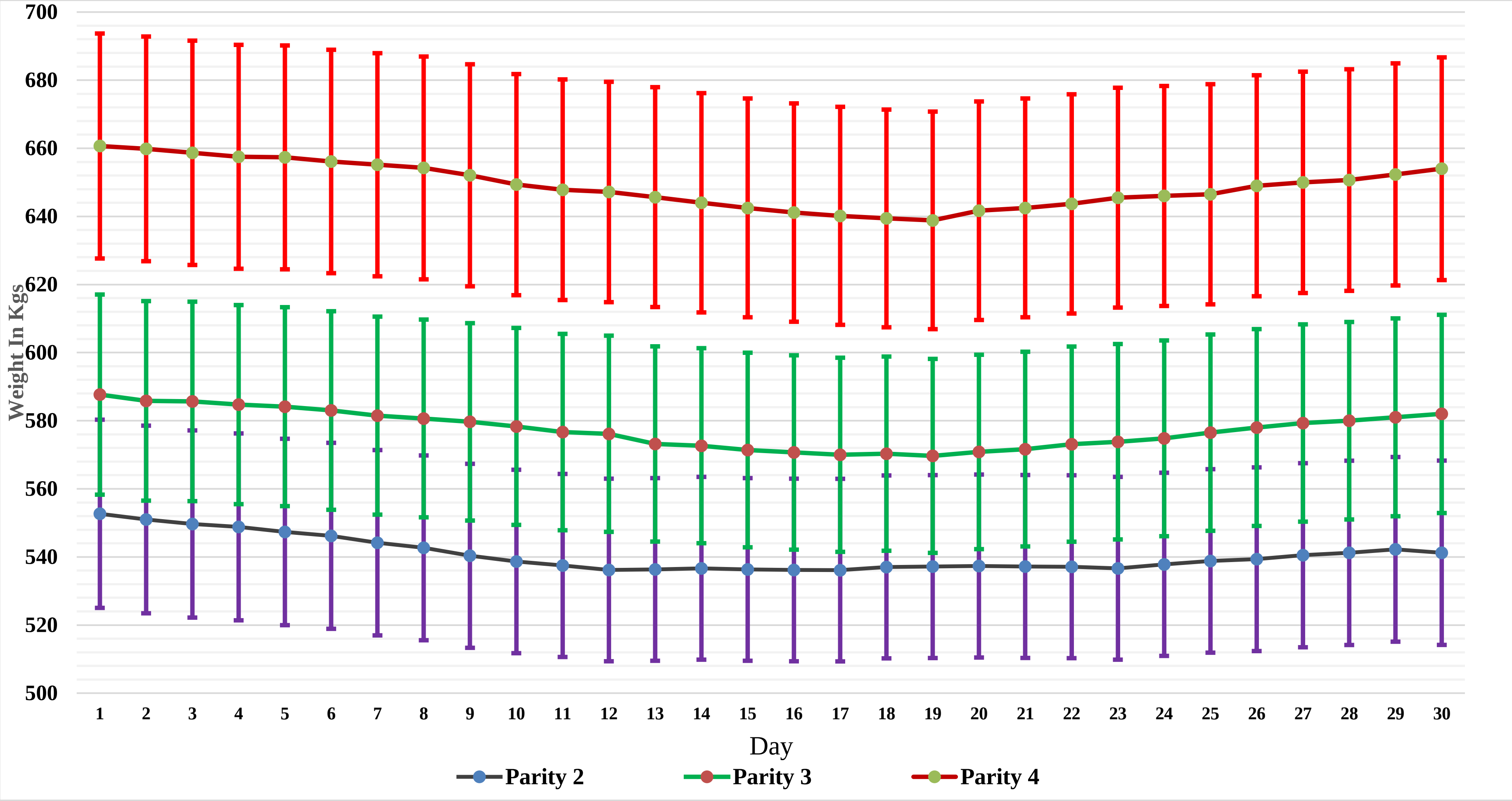
Figure 1: Body Weights of the Dairy Cows in Different Parities during the 30-day Post-parturient Period



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Empirical studies support the phenomenon that feed intake among lactating cows tends to increase up to a body weight of 750 kg and then stagnate or even decline, especially in the genotypes with a high proportion of dairy breeds (Ledinek *et al.,* 2019).

Nutrient Analysis of the Diets

The results in Table 2 show Betan farm diets had better values in Ether extracts (4.52%), Acid Detergent Lignin (ADL) (4.66%), crude protein content (9.62%), Ash content (9.59%) and Metabolizable Energy (ME) (3.001 Mj/KgDM) while Elso Farm had the highest values in Acid Detergent Fibre(ADF) (35.22%) and Neutral Detergent Fibre (NDF) (62.41%) with highest crude protein (CP) content (7.91%) and crude fibre content (30.81%). Elfam had the lowest values in Ash content (6.50%) and crude protein content (7.62%). The nutritional diets significantly differed (p< 0.05), with Betan Farm seemingly having higher nutritional requirements. The study noted the use of feed supplementation by all farms and was not included in the study.

Table 2: Nutrient Composition of Experimental Feeds

	Nutrient Composition in %								**ME** in
Farm	**DM**	**Ash**	**CP**	**CF**	**EE**	**NDF**	**ADF**	**ADL**	MJ/KgDM
Elfam	91.90[a]	6.50[c]	7.62[c]	25.53[b]	1.84[b]	58.60[a]	34.49[a]	4.10[a]	2.370[b]
Elso	91.75[a]	7.91[b]	7.91[b]	30.81[a]	1.89[b]	62.41[a]	35.22[a]	3.27[b]	2.230[b]
Betan	92.03[a]	9.59[a]	9.62[a]	23.16[c]	4.52[a]	53.26[b]	30.52[b]	4.66[a]	3.001[a]
F	0.18	154.24	1390.45	118.53	383.01	15.95	29.21	14.25	244.80
p-value	0.840	0.000	0.000	0.000	0.000	0.004	0.001	0.005	0.000

[a, b, c] Means with different superscripts in a column are significantly different (p<0.05)

DM: Dry Matte, Ash: Mineral content, CP: Crude Protein, CF; Crude Fibre, EE: Ether Extracts, NDF; Neutral Detergent Fibre, ADF: Acid Detergent Fibre, ADL: Acid Detergent Lignin, ME: Metabolizable Energy

In the study, the highest CP content was 9.62%, which is comparatively lower for the nutritional requirements of the lactating cow which is about 14.3% CP to allow for adequate ruminal bacterial growth and efficient fermentation of structural carbohydrates with a concurrent production of significant quantities of microbial protein (Montoya *et al.*, 2017). Apelo *et al.,* (2014) observed that the average CP content in the diets for the dairy cows in US farms is about 17.8 ± 0.1% CP with a mean gross Nitrogen(N) efficiency of 24.7 ± 3.99%. The dietary CP content for immediate post-parturient lactating cows is > 14.7% (Montoya *et al.*, 2017).

Feed Intake by the Dairy Cattle during the Post-parturient Period.

The daily feed intake of the cows was determined, and the findings were graphically illustrated as shown in Figure 2. The average feed intake showed that cows in all parities had their initial intake of between 15 and 17 kg/day and did not significantly (p ≥ 0.05) differ among parities. The trends showed a gradual increase in feed intake from 15 kg/day to an average of 35 kg/day for all the cows. The feed included both dry (hay, concentrate) and wet (silage, Lucerne and Napier grass).

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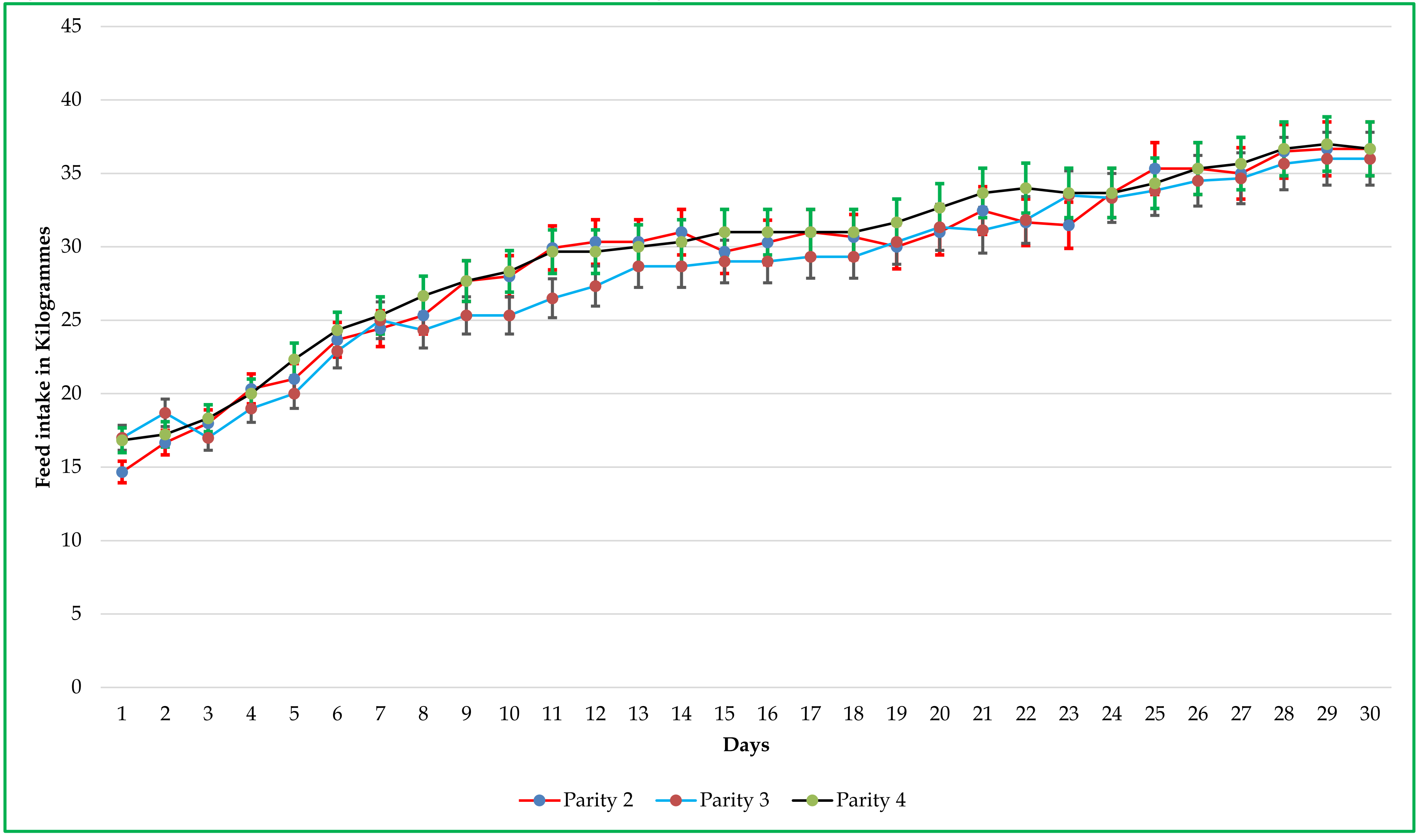
Figure 2: Feed Intake for Friesian Cattle in Different Parities During the 30-day Post-parturient Period



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The study observed a gradual increase in average feed intake from the day from 15 kg of DMI for cows with parity two to 17 kg for cows with parity four, immediately after parturition and a progressive and gradual increase in average feed intake to 35 kg on day 30. The gradual rise in the feed intake is explained by the stress levels, the cow's physiological state and nutrient availability in the feeds as the lactating cows continuously adapt their energy metabolism to the varying energy requirements presented by the lactation cycle (Kenéz *et al.,* 2015).

Dairy cows with higher Body Condition Score (BCS) during the dry period tend to slowly increase their DMI in the immediate post-parturient period before reaching their maximum DMI between 12 to 16 weeks into lactation (Jorritsma *et al.,* 2013). Immediately after the parturition, the losses in the BDS are associated with an NEB nadir that alters the blood hormone and metabolite profiles (Tanaka *et al.,* 2011). Specifically, high NEFA and βHBA concentrations are indicative of the oxidation of fatty acids and mobilisation of lipids (Piccione *et al.,* 2012).

DMI that has high fibre content has low nutrient and energy content. Consequently, high-quality pastures and forages support milk production levels of around 30 kg/day, while high milk productivity is accompanied by considerable lipid mobilisation and/or achieved by concentrate supplementation (Zbinden *et al.,* 2017). However, effective rumen activity requires a balance of ADF and NDF content in the diet (Zebeli *et al.,* 2012). In contrast, high-energy diets (starch-based concentrates) relative to the forage content (> 60%) may result in (subclinical) rumen acidosis (SARA) which consequently retards rumination activity i.e., DMI and rumen passage rate (Neubauer *et al.,* 2020; Humer *et al.,* 2018).

Hormonal Profile of the Friesian Cows during the Post-parturient Period

The hormonal profile of the Friesian cattle is shown in Figures 3, 4, 5 and 6. As indicated in Figure 3, the levels of cortisol hormone of the Friesian cows in different lactation cycles (parities) gradually declined from week 1 to week 4. At parturition, cows in parity (lactation cycle) 2 had elevated cortisol levels of 201 $ngmL^{-1}$ and were significantly different ($p < 0.05$) from cows in parity 3 (142 $ngmL^{-1}$) and parity 4 (120 $ngmL^{-1}$). All the cows in different lactation cycles (parities) significantly reduced the levels of cortisol hormone to reach low levels of 112 $ngmL^{-1}$ (parity 2), 84 $ngmL^{-1}$ (parity 3) and 72 $ngmL^{-1}$(parity 4) by week 4. As the cortisol hormone quantity dropped significantly, indicating a reduction in the stress levels, the cows tended to increase feed intake (Figure 2) to satisfy the nutritional requirement in the post–parturient period.

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Figure 3: Serum Cortisol Levels

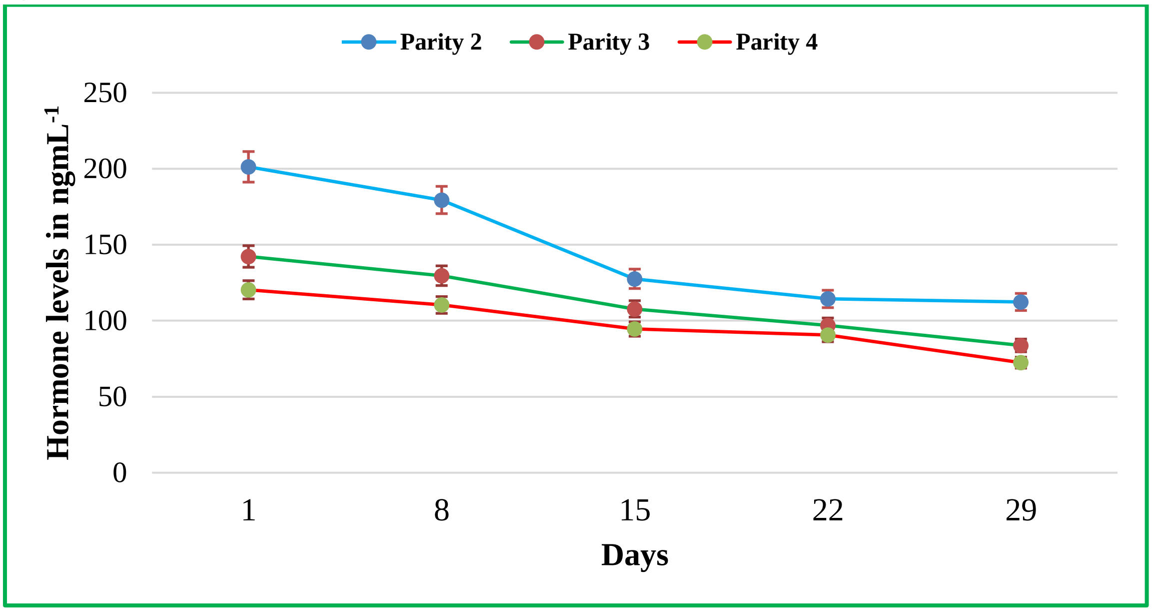

Figure 4 shows that the levels of prolactin hormone quadrupled from an average of 84.3 $ngmL^{-1}$ for the different parities in week 1 to 350.8 $ngmL^{-1}$ in week 4 for different parities accordingly. At parturition, the cows in parity 2 had the lowest prolactin levels at an average of 61 $ngmL^{-1}$ and were significantly different ($p < 0.05$) from cows in parity 3 (76 $ngmL^{-1}$) and in parity 4 (116 $ngmL^{-1}$). The prolactin levels gradually rose with the increase in feed intake (Figure 2) to an optimal amount of 307 $ngmL^{-1}$ (parity 2), 344 $ngmL^{-1}$ (parity 3) and 400 $ngmL^{-1}$ (parity 4) by week 4. As the feed intake increased, there was a significant rise in prolactin hormones to optimise milk production as the lactating cows stabilized the nutritional requirement in the post–parturient period.

Figure 4: Serum Prolactin Levels

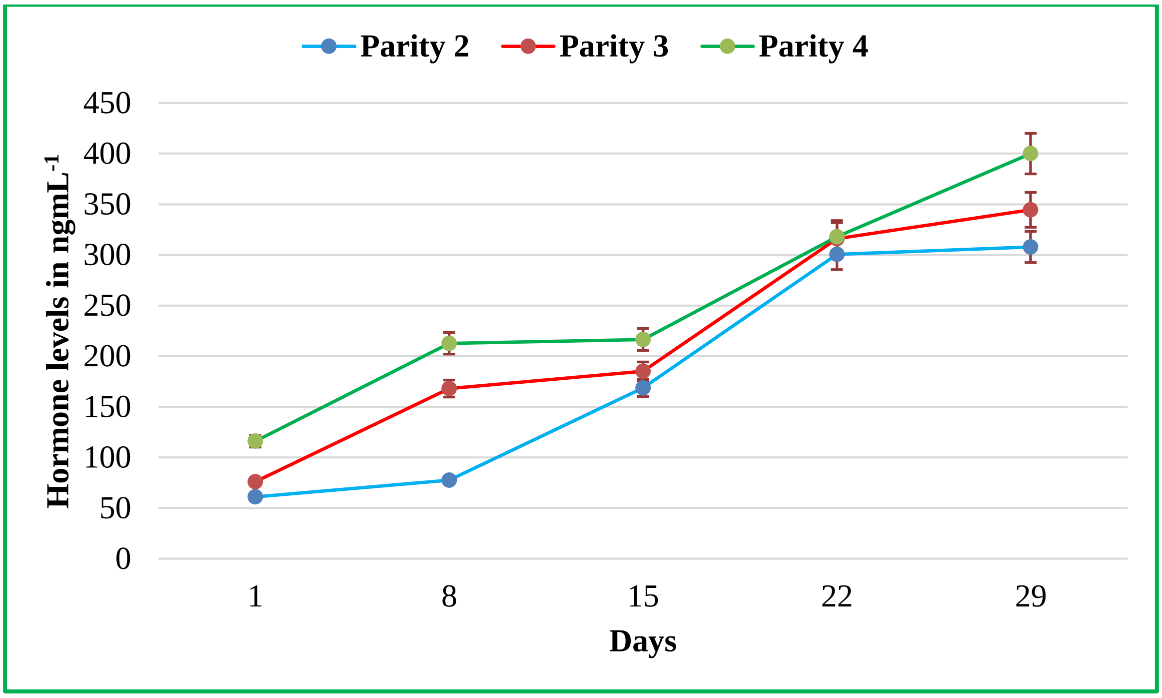

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Figure 5 shows that the levels of oestrogen hormone tripled from an average of 1.2 $ngmL^{-1}$ for the different parities in week 1 to 3.6 $ngmL^{-1}$ in week 4 for different parities accordingly. At parturition, the cows in parity 2 had the highest oestrogen levels at an average of 1.41 $ngmL^{-1}$ and were significantly different ($p < 0.05$) from cows in parity 3 (1.14 $ngmL^{-1}$) and parity 4 (1.05 $ngmL^{-1}$). The serum oestrogen levels gradually rose with the increase in feed intake (Figure 2) to an optimal amount of 4.07 $ngmL^{-1}$ (parity 2), 3.48 $ngmL^{-1}$ (parity 3) and 3.15 $ngmL^{-1}$ (parity 4) by week 4. As the feed intake rose, there was a gradual increase in the oestrogen hormone levels as the Friesian cows sought to stabilise the oestrus cyclicity for the next lactation cycle.

Figure 5: Serum Oestrogen Levels

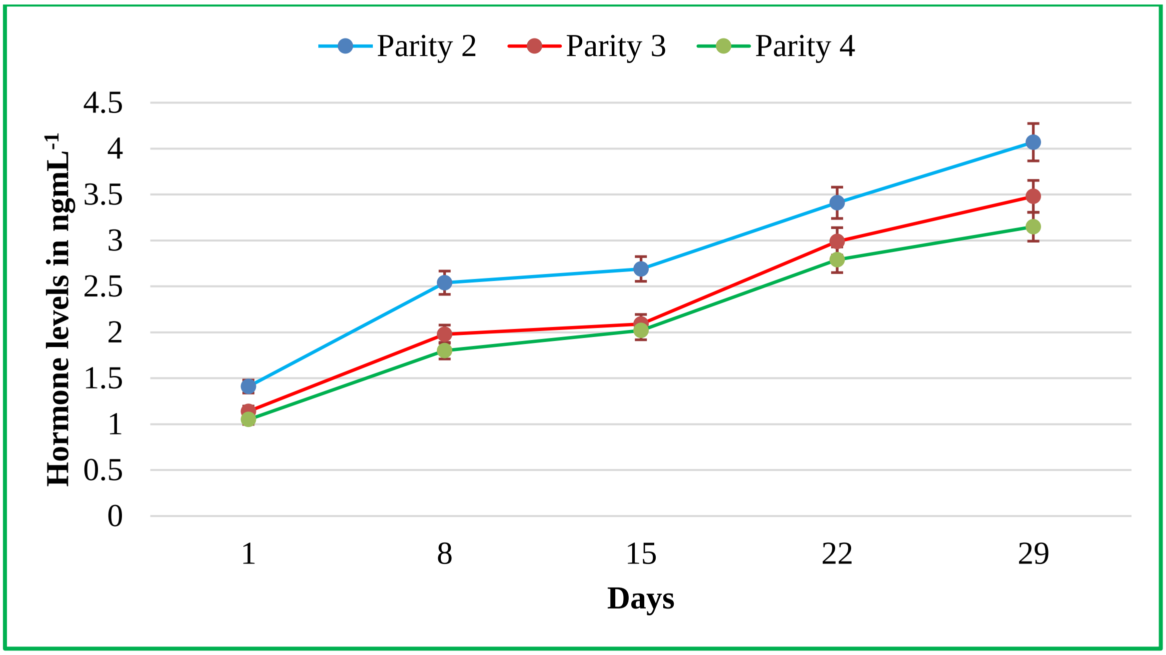

Figure 6 shows that the levels of Insulin Growth Factor (IGF-α1) hormone tripled from an average of 110 $ngmL^{-1}$ for the different parities in week 1 to 325 $ngmL^{-1}$ in week 4 for different parities. At parturition, the cows in parity 4 had the lowest IGF-α1 levels at an average of 81 $ngmL^{-1}$ and were significantly different ($p < 0.05$) from cows in parity 3 (115 $ngmL^{-1}$) and parity 2 (133 $ngmL^{-1}$). The serum IGF-α1 levels gradually rose with the increase in feed intake (Figure 2) to an optimal amount of 280 $ngmL^{-1}$ (parity 4), 327 $ngmL^{-1}$ (parity 3) and 367 $ngmL^{-1}$(parity 2) by week 4. As the feed intake rose, there was a discernible increase in the IGF-1 hormone levels as the Friesian cows sought to support their normal bodily growth functions and needs

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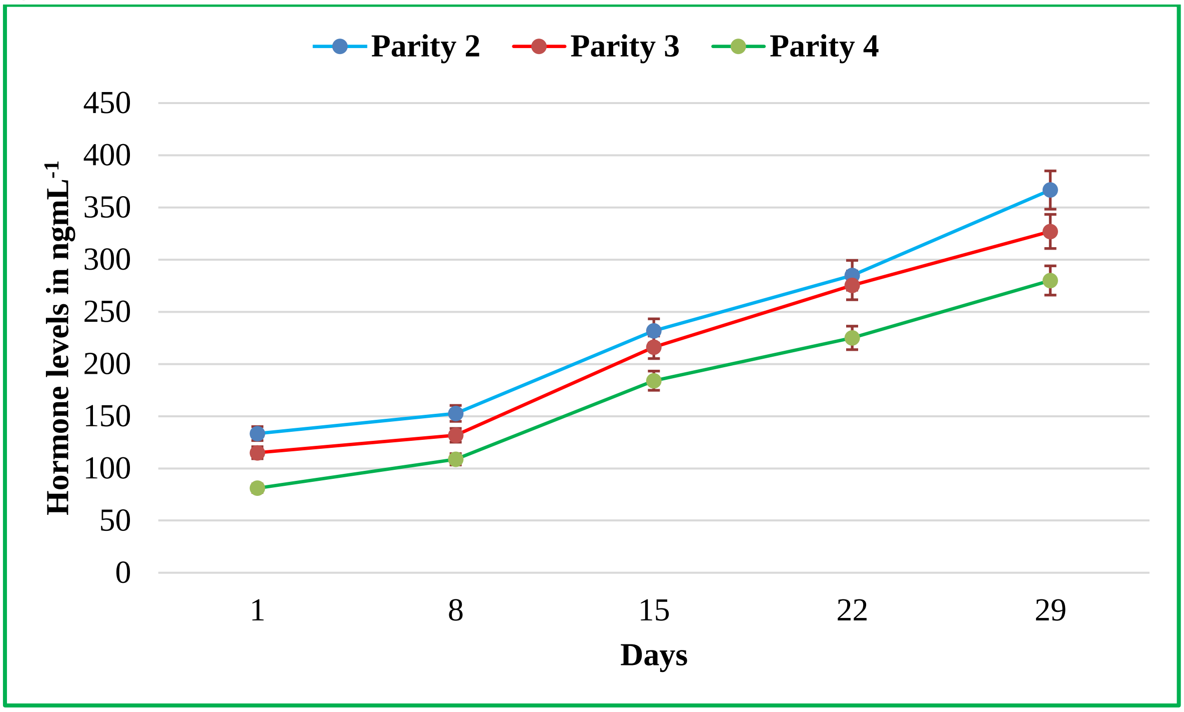
Figure 6: Serum Insulin Growth Factor-α1 Levels



The study then examined the association between feed intake and hormone levels using correlation statistics, and the results are presented in Table 3 below.

Table 3: Correlations Between Feed Intake and Hormonal Levels of the Post-parturient Friesian Cows

	Feed Intake	Cortisol	Prolactin	Oestrogen	IGF
Feed Intake	1				
Cortisol	-0.613**	1			
Prolactin	0.760**	-0.692**	1		
Oestrogen	0.785**	-0.464**	0.851**	1	
IGF-α1	0.692**	-0.645**	0.851**	0.735**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3 indicated that feed intake significantly and positively correlated to prolactin hormone ($r = 0.760$, $p < 0.01$), Oestrogen hormone ($r = 0.785$, $p < 0.01$), and IGF ($r = 0.692$, $p < 0.01$) but negatively ($p < 0.01$) correlated ($r = -0.613$) to cortisol hormone. This showed that feed intake largely and positively influences hormone levels (Prolactin, IGF and Oestrogen) such that, where there is an increase in the amounts of feed consumed by the lactating cows in the immediate post–parturient period, there is a commensurate increase in hormone levels. Only the cortisol hormone has a highly significant ($p \leq 0.01$) negative effect on feed intake, implying that the higher levels of cortisol hormone have an inverse effect with lactating cows tending to have lowered feed intake and on the converse, lower levels of cortisol hormone tend to lead to higher feed intake.

At parturition, the cows in lactation cycle (parity) 2 encountered higher stress levels as indicated by elevated cortisol hormones of 201 $ngmL^{-1}$ and as the cortisol levels dropped, the serum IGF-α1 levels gradually rose from 133 $ngmL^{-1}$ in week to 367 $ngmL^{-1}$ by week 4 to support the normal growth requirements for cows in lower parities. Thus, the body weight of animals in lower parity (lactation cycle) 2 was significantly lower (Figure 1) when compared to cows with parity 3 and 4. As

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the serum IGF-α1 hormones rose, there was a significant increase in the feed intake to compensate for the NEB, stabilised nutritional requirements and optimize milk production, and thus, the serum prolactin levels of cows in parity 2 surged from an average of 61 $ngmL^{-1}$ in week 1 to 307 $ngmL^{-1}$ in week 4, (parity 2), to support the lactation requirements of the post-parturient period. Based on the homeorhetic balance, a lactating cow in parity 2 also seeks to regulate its oestrus cycle and thus the gradual increase in serum oestrogen levels of 1.41 $ngmL^{-1}$ in week 1 to 4.07 $ngmL^{-1}$ by week 4. The physiological hormone changes in the post-parturient period weigh heavily on lactating cows depending on their nutritional status

At parturition, the cows had low prolactin levels with concurrent NEB and low feed intake (Figure 2) because of the cortisol hormone. Prolactin, a hormone crucial for milk secretion during lactation, plays a multifaceted role in the development, differentiation, and functioning of mammary tissues, as well as in supporting the corpus luteum's function (Biswas *et al.*, 2022). Prolactin directly affects mammary gland functions, but the responsiveness of the mammary gland to prolactin appears to be modulated by local and systemic factors (Zhang *et al.*, 2024). The basal prolactin concentration is affected by the environment and changes throughout the year without similar changes in milk yield, suggesting that the mammary gland adapts to the prolactin levels (Tong *et al.*, 2018).

The trends in the levels of oestrogen hormone indicate that cows of parity 2 tend to return to the oestrus cycle earlier than those in parity 3 and parity 4. An increase in the concentration of oestrogens during the perinatal period in cattle is associated with the preparation of the mammary gland for lactation and increased enzymatic activity of the mammary gland. A higher concentration of estrone sulphate and other oestrogens was noted from mid-pregnancy until the expulsion of the placenta. A rapid increase in prolactin is observed in the last two weeks of pregnancy. In early lactation, a rapid decline in oestrogen is observed (Kurpińska & Skrzypczak, 2020). 14 days before parturition, the oestrogen concentration rapidly increases, with the highest oestrogen levels recorded on the parturition day but the oestrogen concentration decreases thereafter (Kurpińska & Skrzypczak, 2020).

The phenomenon is explained by the physiological changes which collectively represent the metabolic load, which imposes a burden on the lactating by calling for the synthesis and secretion of milk. With increasing production levels, the sudden high nutrient demand for milk production after parturition (Hernández-Castellano *et al.*, 2017). Milk production, which starts immediately after parturition at a rather high level and increases further despite energy deficiency, correlates with the amounts and peak values of milking-induced prolactin release (Zhang *et al.*, 2024). Furthermore, IGF-1 plays an important role in the growth and function of the mammary glands by influencing the stimulation of protein synthesis in the epithelial cells of the mammary gland.

The increased milk production has been implicated with increased activity of lipolytic enzymes in adipose tissue, and with greater expression of genes involved in body fat mobilisation. Low glucose and insulin concentrations are associated with elevated concentrations of non-esterified fatty acids and ketone bodies post-parturient have disruptive and detrimental effects on the oocyte, granulosa and immune cells (Bisinotto *et al.*, 2018).

The dietary ME utilisation is affected by the type of diet because changes in dietary composition alter the pattern of available nutrients for milk and tissue synthesis (Moraes *et al.*, 2015). Cows in immediate post-parturient derive their nutritional requirements in terms of Energy, protein and minerals from the DMI and have greater requirements of Metabolisable Protein, Metabolisable Energy, and minerals than cows in early lactation and thus tend to exhibit a negative energy balance (Montoya *et al.*, 2017). Changes in body weight and BCS are proxies for energy balance and may reflect the nutritional balances of

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protein, minerals, specific fatty acids and vitamins, as well as energy (Rodney *et al.*, 2018).

Based on the trends in the levels of IGF hormone indicate that cows with parity 2 tend to return to regulate their growth than those in parity 3 and parity 4. Insulin-like growth factor-1 (IGF-1), among other hormones, are all dramatically changed during the early lactation period to mediate the required metabolic adaptations (Singh *et al.*, 2014). However, IGF-1, like other hormones, is also involved in the follicular development and the re-establishment of cyclic activity post-parturient, and their characteristics change during the metabolic adaptation, negatively influencing ovarian activity (Kawashima *et al.*, 2012).

CONCLUSION

The study observed a causal relationship between feed intake and hormone levels of the lactating Friesian cows in the immediate post–parturient period. The levels of prolactin, oestrogen and IGF hormones gradually rose after parturition with a commensurate increase in the amount of feed consumed by the cow. However, the levels of cortisol hormone reduced gradually. The conclusion is that feed intake plays a key role in sustaining the metabolic and physiological state of a lactating cow in the immediate post-parturient period by influencing the hormone levels.

Recommendation

Since the hormonal profile of a lactating cow influences the cow's physiological state during the lactation period, farmers should improve or alter the nutritional diets to accommodate the changing physiological needs of the post–parturient lactating cow. Each physiological state of the cow should be accompanied by appropriate nutritional requirements such as the increase in the protein content to an average of 15 %, altering the ratio of concentrate to forage to 60:35 to accommodate the peri-parturient to post–parturient period and reengineering the said ratios of protein to less than 10 % during the late lactation to improve on the nutritional efficiencies of the dairy cow.

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