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Arbeitsgruppe Tierernährung

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Effect of duration on a high-starch diet on fecal pH and particle size in Simmental Cows

Diploma Thesis

University of Veterinary Medicine Vienna

submitted by

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Vienna, November 2025

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Declaration of Independence:

I hereby declare that I have written the submitted work myself and have used no aids or sources other than those stated. All text passages taken from external sources have been cited. I have carried out the important work myself and named all those who helped and contributed. The present work has not been submitted or published anywhere else. No AI was used in the writing of this work.

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Abstract

This study aims to evaluate the changes in fecal pH, fecal particle size, and rumen pH during high starch feeding. These factors give insight into the fermentation dynamics and health of dairy cows. 39 lactating Simmental cows were transitioned to 50 % concentrate feed and used over two 28-day experimental periods. Measurements of fecal pH, ruminal pH and fecal particle size distribution were conducted on days 14 and 28. Data were analyzed using SAS, with experimental day as fixed effect and cows as random effect.

Results show a significant rise in fecal pH and a change in fecal particle size distribution but no statistically significant change in rumen pH. Specifically, fecal pH rose by 0.24 ($P < 0.05$) with a minimum of 6.34 on day 14, and 6.98 on day 28. Particle size distribution shifted to significantly higher soluble fraction ($P < 0.05$) on day 28. There was significant correlation between fecal particle size and fecal pH but no significant correlation with ruminal pH. Specifically, there was a negative correlation between fecal pH and the largest particles (> 4 mm; > 2 mm) ($P < 0.05$), and a positive correlation with the soluble fraction (< 0.15 mm) ($P < 0.05$).

The study concludes that fecal pH and the larger fecal particle size fractions shifts towards ranges similar to those seen with forage feeding. However, not all of the evaluated parameters showed the same trend during extended high starch feeding.

Zusammenfassung

Diese Studie evaluierte die Veränderungen des pH-Werts von Kot und Panseninhalt, sowie die Partikelgröße des Kots, während stärkereicher Fütterung. Diese Faktoren erlauben Einsicht auf Fermentationsdynamik und Gesundheit der Milchkühe. 39 laktierende Fleckviehkühe, auf zwei Versuchszeiträume aufgeteilt, wurden an eine 50 % Konzentrat Mischung gewöhnt und vier Wochen mit dieser gefüttert. Kot-pH, Pansen-pH und Kotpartikelgrößenverteilung wurden an Tag 14 und Tag 28 gemessen. Die Daten wurden mithilfe des Programms SAS analysiert, mit dem Tag der Probeziehung als fester Effekt und die Einheit Kuh als Zufallsfaktor.

Ergebnisse zeigten am Ende des experimentellen Zeitraums einen signifikanten Anstieg des Kot-pHs und eine veränderte Verteilung der Kot-Partikelgröße, aber keine statistisch signifikante Änderung des Pansen-pHs. Im Detail stieg der pH-Wert im Kot um 0,24 ($P < 0,05$), wobei das pH-Minimum an Tag 14 bei 6,34 lag, und and Tag 28 bei 6,98. Die Partikelgrößenverteilung änderte sich zu Gunsten der löslichen Fraktion ($P < 0,05$) am Tag 28. Es zeigte sich ein Zusammenhang zwischen Partikelgrößenverteilung und Kot-pH, aber keine signifikante Korrelation mit dem Pansen-pH. Insgesamt ergab sich eine negative Korrelation zwischen Kot-pH und den größten Partikeln (> 4 mm; > 2 mm) ($P < 0,05$), und eine positive Korrelation mit der löslichen Fraktion (< 0,15 mm) ($P < 0,05$).

Zusammenfassend ergab sich im Rahmen der Studie, dass sich einzelne Parameter während einem längeren Zeitraum stärkereicher Fütterung denen annähern, die bei Fütterung mit weniger Konzentrat zu erwarten wären. Dies ist aber nicht bei allen Parametern so.

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List of abbreviations

ADF	Acid Detergent Fiber
CP	Crude Protein
DM	Dry Matter
ECM	Energy Corrected Milk
EE	Ether Extract
Fig.	Figure
NDF	Neutral Detergent Fiber
NFC	Non-Fiber Carbohydrates
pef	physical effectiveness factor
peNDF	physically effective Neutral Detergent Fiber
PSPS	Penn-State Particle Separation
SARA	Subacute Rumen Acidosis
TMR	Total Mixed Ration

1. Introduction

There are different dairy farming systems, ranging from low-maintenance extensive farming using dual-use cattle, to intensive systems employing cows bred for milk. These different kinds of management also require different diets to support the metabolism and milk yield – forage feed by itself will not be sufficient to meet the nutritional requirements of high-yielding cows. High concentrate diets have long become the standard in intensive dairy production, due to their various advantages, like faster growth, more milk, and a higher feed efficiency (1,2). However, these diets also have disadvantages. Besides the higher cost, especially if grain and silage is not also grown by the cattle farmer, diets with a higher concentrate percentage also have an effect on the cows. Compared to forage, concentrate has less physically effective fiber (peNDF) and more starch to be metabolized by the gut microbiota. As such, it predisposes cows to subacute ruminal acidosis (SARA) (3) which is said to occur when minimum ruminal pH reaches below 5.8 for at least 330 min/day (4,5).

There have already been many studies researching the effects of high concentrate diets (6–13). These studies are conducted often with a limited number of animals, but almost all focusing on a comparison between forage (or otherwise low-starch) diet and various levels of concentrate. In this study, we focused on the changes of the fermentation dynamics and pH levels in cows that have already recently transitioned from a 37 % to a 50 % concentrate diet.

For this, we focused on fecal characteristics. Previous research has often made use of permanent rumen cannulae (14,15), rumenocentesis (16,17), or indwelling pH measurement devices (6,18), which have their advantages but also come with higher costs and, in the case of cannulae and ruminocentesis, are invasive. Fecal samples are far less invasive and more easily accessible indicators of hindgut fermentation, fiber degradation during the digestive process, and flow of undigested nutrients through the intestine, compared to alternative options. The three indicators used in this study were rumen pH, to correlate with the other changes, as well as fecal pH and particle size distribution. These factors have been proven to be good indicators of ruminant health. High concentrate diets are known to increase the amount of starch passing through the rumen, which is not digested and reach the lower gut (19), leading to lower fecal pH (20,21). Furthermore, the fermentation dynamics in rumen and hindgut combined with less chewing

lead to a different distribution of fecal particle sizes (22,23). Thus, the evaluation of fecal fermentation and physical characteristics may provide a less invasive approach to estimate the impacts of high-concentrate feeding on the lower gut; conversely, the evaluation of fecal properties may provide an estimation of ruminal conditions.

Consequently, this study assessed the changes in fecal pH, fecal particle size distribution, and ruminal pH during an extended period of high concentrate feeding. We hypothesized that we would find the cows adapting to the high-concentrate diet and that some of the parameters would shift towards to a healthy physiological condition (mean ruminal pH between 6 and 6.5, fecal pH of 7, and a fecal particle size distribution with lower soluble fraction) previously established by other authors (6,10). Moreover, we hypothesize that lower ruminal pH will be reflected in the fecal pH as well as a shift in fecal particle size.

2. Materials and Methods

2.1. Experimental design and Cow management

This study was conducted on 39 lactating Simmental cows (mean age 5.57 ± 2.44 years, mean lactation number of 3.38 ± 2.34; 194.48 ± 71.55 days in milk, and initially producing 33.30 ± 6.11 kg of ECM. Mean BW at the start of the trial was 761.4kg ± 89.24kg) from the "vetfarm" research farm (Kremesberg, Pottenstein) of the University of Veterinary Medicine Vienna. A statistical power analysis was conducted before the start of the project (see *2.8. Statistical Analysis*) to determine an effective number of animals.

The experimental period consisted of 28 days, including 3 days for the cows to adapt to the feeding routine and be taught how to use the individual feeding troughs. Sampling was done on days 14 and 28 for most of the evaluated parameters. The experiment included two successive experimental periods. In each period 20 and 19 cows were used, respectively. There was no overlap between groups. The two groups of cows were kept in a free-stall barn equipped with deep litter cubicles (2.6 × 1.25 m) cushioned with straw, *ad libitum* water and feed, as well as free-choice mineral blocks. Individual feed intake was automatically measured using feed bunks hat had weighing scales as well as access gates that responded to the cows' ear tags (Insentec B.V., Marknesse, Netherlands).

The total mixed ration (TMR) was mixed every morning using an automated feeding system (Triolet Triomatic T15, Oldenzaal, Netherlands) and distributed twice daily, at 0800h and 1430h. Due to the dry nature of the TMR, water was added during mixing with the goal of having 47 % dry matter (DM). Composition of the TMR on DM basis is listed in Table 1 and its chemical composition in Table 2. Before filling the feed bunks, refuse from the previous day was collected, weighed, and discarded. Before they were transitioned to the 50 % concentrate diet during the experimental periods, the cows had been fed a 37 % concentrate diet.

The experiment was approved by the Ethics and Animal Welfare Committee of the University of Veterinary Medicine, Vienna, in accordance with the University's Guidelines for Good Scientific Practice and authorized by the Austrian Federal Ministry of Education, Science and Research (Protocol # 2023-0.841.014) in accordance with current legislation.

2.2. Feed sampling, evaluation and analysis

Feed was sampled at the end of week 2 (around day 14) and at the end of week 4 (around day 28) after switching to the 50 % concentrate diet and frozen immediately after sampling at -20 °C for later laboratory analysis.

All nutrient analyses of feed samples were evaluated in duplicate according to the German Handbook of Agricultural Experimental and Analytical Methods (VDLUFA). Composition of the feed was analyzed weekly and adjusted as needed to fit the intended diet composition. For this purpose, DM was determined daily at the barn by drying for 24h at 100 °C. In the laboratory, samples were dried in a forced-air oven at 65 °C for 48h to determine a more accurate dry matter value, then put in a muffle furnace overnight at 580 °C to do determine ash content. Starch content was measured with the total starch assay kit (K-TSTA) by Megazyme Ltd. Ether Extract (EE) was washed out and measured using a Soxhlet extraction system and crude protein (CP) was determined with the Kieldahl method (24). Total neutral detergent fiber (NDF) and acid detergent fiber (ADF), were measured with the use of sodium sulfite to remove protein contaminants and α-amylase for starch, excluding residual ash, following VLDUFA protocol. NDF was then further split into potentially digestible and indigestible fiber by leaving a known weight of sample in the cows' rumen for 48 hours and weighing how much was digested. Acid detergent lignin was gravimetrically determined after ADF separation with 72 % sulfuric acid. Non-fiber carbohydrates (NFC) were calculated using the formula "100 - (%ash + %EE + %CP + %NDF)".

2.3. Feed particle size

To determine physical effectiveness factor (pef) and through that physically effective fiber (peNDF) as outlined by Beauchemin and Yang, 2005 (25), particle size distribution of the diets was to be evaluated. The method used for calculating pef was Penn State Particle Separation, using a 3-screen PSPS (model C24682N, Nasco, Fort Atkinson, WI) as per the method used by Kononoff et al., 2003 (26) to separate TMR samples into 4 fractions: long (> 19 mm), medium (> 8 mm), short (> 1.18 mm), and fine (< 1.18 mm). The pef was then defined as the sum of the

fractions of particles that remained on the respective sieve and all above it (so for pef > 8 mm it would be the > 19 mm fraction + the > 8 mm fraction) and is a number between 0 and 1. The peNDF of the diet was then calculated by multiplying its pef by the previously measured NDF.

To allow further analysis of the diet, and for easier comparison of feed and fecal particle size, particle size distribution of TMR was also measured in duplicate using a vertical oscillating sieve shaker (AS 200 Digit Analytical Sieve Shaker, F. Kurt Retsch GmbH & Co. KG, Haan, Germany, 200 mm diameter) using 7 sieves (pore sizes of 8.0 mm; 5.0 mm; 4.0 mm; 2.0 mm; 1.18 mm; 0.5 mm; and 0.15 mm) following a schema similar to Khorrami et al. (2022) (6). After thawing the full sample, a representative 40 g of feed were soaked in 400 ml of pure (WEK) water for an hour at room temperature. The feed was placed and evenly distributed on the top sieve, and any particles remaining in the beaker were washed onto the sieve with more pure water. The sieve tower was sealed and set to shake for 12 minutes with an amplitude of 2 mm and intervals of 20 seconds followed by 2 seconds of pause, while water was evenly sprayed onto the top sieve. Afterwards, content of each sieve was transferred onto a paper filter of known weight (using tweezers if needed). Filters were dried in an oven at 100 °C before being weighed. Distribution of feed particle size was estimated by comparing the weights of the dry contents of each sieve with the total dry matter previously measured. The difference between sum total of contents and dry matter was assumed to be the particles escaping the 0.15 mm screen (the soluble fraction).

Ingredients of the high starch diet used for the experimental period are detailed in Table 1. The chemical composition and particle sizes (PSPS and oscillating sieve shaker) are listed in Table 2.

Table 1. Ingredient Composition of the total mixed ration fed during this experiment

Ingredients	**% of DM**
Grass silage	25.0
Corn silage	25.0
Rindastar SM Vet	27.0
Rindastar 39 % XP	15.0
Kuhkorn Kompakt 19	8.0

Table 2. Analyzed data of chemical composition and particle size distribution of the experimental diet, average of period 1 and period 2 (no notable differences between periods)

Chemical composition (% of DM unless stated)	**Week 1**	**Week 2**
Dry Matter, % of fresh matter	46.33	46.02
Ash %	7.55	7.37
Starch %	24.86	25.82
Ether Extract %	2.15	2.19
Crude Protein %	17.26	17.86
Neutral Detergent Fiber %	34.39	31.63
Potentially Digestible NDF %	12.14	12.3
Indigestible NDF %	22.25	19.32
Acid Detergent Fiber %	24.71	21.19
Acid Detergent Lignin %	4.98	4.96
Non-Fiber Carbohydrates %	38.65	40.96

Particle Fractions (PSPS)	**Week 1**	**Week 2**
Long (>19 mm) %	8.80	6.42
Medium (>8 mm) %	55.3	55.2
Short (>1.18 mm) %	29.05	32.6
Fine (<1.18 mm) %	6.82	5.74
pef > 8 mm	0.64	0.62
pef > 1.18 mm	0.93	0.95
peNDF > 8 mm %	22.05	19.43
peNDF > 1.18 mm %	32	29.75

Particle Fractions (Oscillating Sieve Shaker)	**Week 1**	**Week 2**
8 mm %	12.37	17.17
5 mm %	3.11	2.94
4 mm %	2.14	1.92
2 mm %	5.60	5.15
1.18 mm %	3.68	3.66
0.5 mm %	10.01	8.58
0.15 mm %	10.54	8.09
Soluble %	52.55	52.51

2.4. Fecal sampling and analysis

Similar to feed samples, the fecal samples were collected at the end of week two (around day 14) and at the end of week 4 (around day 28). Samples were taken over 3 days, in the morning just before feeding and in the afternoon. The samples were collected directly from the rectum using disposable palpation gloves, pooled together, and immediately frozen at -20 °C. Part of the morning samples was also used for on-farm wet sieving.

2.5. Fecal pH

To measure the relationship between ruminal and fecal pH, both kinds of samples were taken and analyzed in a similar manner. Fecal samples were measured in duplicate or triplicate (Run 1 Week 2 had smaller sample amounts stored in plastic tubes, not allowing more than two measurement locations per sample. For subsequent samples we were able to measure in triplicate) using a portable pH meter (Mettler-Toledo, AG; Analytical CH; Schwerzenbach, Switzerland) and a sub-section of the same samples that were used for fecal particle size measurement. The pH measurement was calibrated with buffers of pH 4 and pH 7 at the start of each day. The electrode was rinsed with pure water and dried between each measurement.

2.6. Fecal particle size

During the experiment, on-farm particle size analysis was performed on fresh samples. An approximate 200 g of fresh feces was soaked in 1 L of tap water for 15 minutes. The soaked sample was homogenized and transferred to a manual particle separator set up with three sieves (arranged by descending pore sizes of 2.0 mm; 1.18 mm; and 0.5 mm) and washed down with tap water until wastewater came back visually clear. Contents of the sieves was weighed, and calculations of fecal particle size was conducted.

After collection of all samples, more detailed particle size measurement was conducted on frozen and thawed fecal samples using an automatic sieve shaker (AS 200 Digit Analytical Sieve Shaker, F. Kurt Retsch GmbH & Co. KG, Haan, Germany, 200 mm diameter). Unlike feed analysis, five sieves (sizes 4.0 mm; 2.0 mm; 1.18 mm; 0.5 mm; and 0.15 mm) were used, following similar protocol as Khorrami et al., 2022 (6); originally based on Zebeli et al., 2007 (7). After thawing and sufficiently homogenizing the full sample, 20 g of feces were soaked and stirred in 400 ml of pure (WEK) water for an hour at room temperature. The sample was

transferred into the sieve tower before being sprayed and shaken for 15 minutes at an amplitude of 2 mm and intervals of 20 seconds with 2 second pauses. Finally, sieve content was transferred, dried, and measured in the same manner as with the feed analysis.

2.7. Ruminal pH sampling and analysis

Rumen fluid samples were collected with a stomach tube on day 14 and day 28, 4 hours after feeding. They were filtered through 4 layers of gauze and transferred to 2 ml tubes before being frozen at -20 °C.

Similar to fecal pH, rumen samples were measured in triplicate using the same portable pH meter, which was previously calibrated with buffers of pH 4 and pH 7. The electrode was rinsed with distilled water and dried between each measurement.

2.8. Statistical analysis

The data collected were analyzed with the PROC MIXED of SAS (SAS Institute, North Carolina, USA; version 9.4). The statistical model included the fixed effects of experimental day and the random effect of cow within each run. The comparison of means was performed using the LSMEAN statement and the PDIFF option. Correlation analysis was conducted with the PROC CORR of SAS. This study was part of a larger project. A statistical power analysis was conducted before the start of the project using a subsample of data of parameters from a previous experiment with PROC POWER of SAS. To do so, the data were subjected to the analysis of statistical power. The power analysis suggested that a statistical test with a 0.05 two-sided significant level would have 90 % power to detect a difference with the number of animals used in this experiment.

Statistical significance was declared when $P \leq 0.05$ and tendency when $0.05 \leq P \leq 0.10$.

3. Results

There were no significant differences between the two experimental periods, and results shown here were calculated using combined data of both periods.

3.1. Fecal and ruminal pH

Results show a significant increase in fecal pH over the course of the experimental period. Measurements ranged from 6.34 to 7.27 on day 14, and from 6.98 to 7.38 on day 28. The mean pH of day 14 was 6.79 compared to day 28 with 7.04. This is a difference of 0.24 ± 0.04 ($P < 0.05$).

Ruminal pH showed no significant changes. Measurements ranged from 7.24 to 8.31 on day 14, and from 7.35 to 7.69 on day 28. The difference between day 14 and 28 is 0.05 ± 0.14 ($P > 0.1$). Mean pH was 6.97 on day 14 and 6.92 on day 28.

Change in fecal and ruminal pH as well as standard error is shown in figure 1.

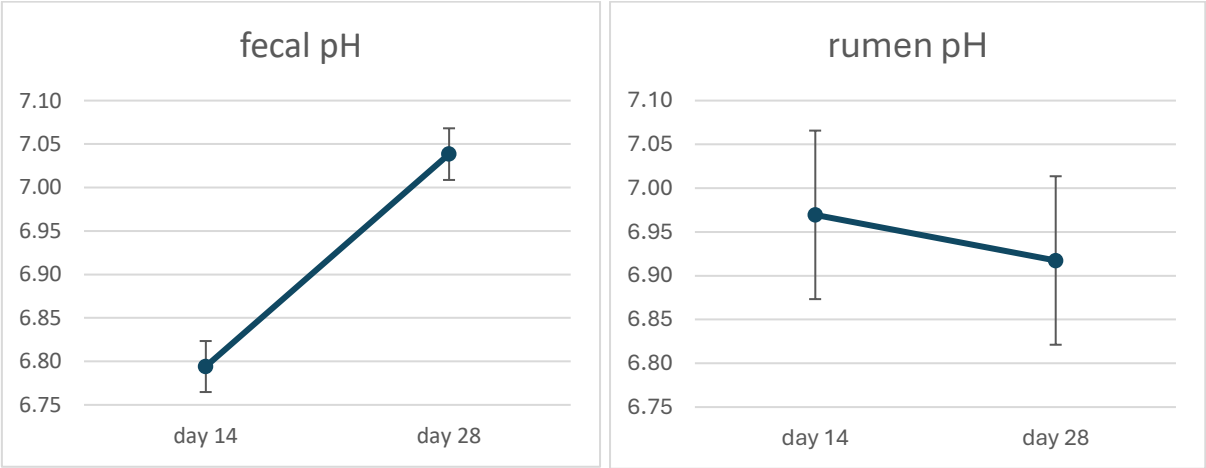

Figure 1a. Fecal and **b**. ruminal pH means on days 14 and 28 (combined run 1 and run 2) of high starch feeding, standard error on each day shown using error bars

3.2. Fecal particle size distribution

The most notable change from 4 weeks of high concentrate feeding was the largest and smallest particle sizes; the long fibers retained on the highest sieve and the soluble fraction that passed

through the 0.15 mm pore size sieve. Overall, results show that every size of sieve retained more material in the day 14 samples than in the day 28 samples.

Between day 14 and day 28, the fraction of > 4 mm particles decreased from 4.09 % to 3.02 % (standard error 0.41 %; $P < 0.05$), > 1.18 mm particles decreased from 4.50 % to 3.56 % (standard error 0.39 %; $P < 0.05$), and > 0.15 mm particles decreased from 22.98 % to 21.39 % (standard error 0.72 %; $P < 0.05$). The soluble fraction, particles < 0.15 mm in size, increased from 52.40 % to 57.29 % (standard error 1.57 %; $P < 0.05$).

The fraction of > 2 mm particles showed a trend to decrease from 3.84 % to 3.05 % (standard error 0.40 %; $P < 0.1$). The drop the > 0.5 mm particle size fraction showed was not statistically significant (12.19 % to 11.67 %; standard error 0.44 %; $P > 0.1$).

Fecal particle size distribution with standard error of each day is illustrated in Fig. 2

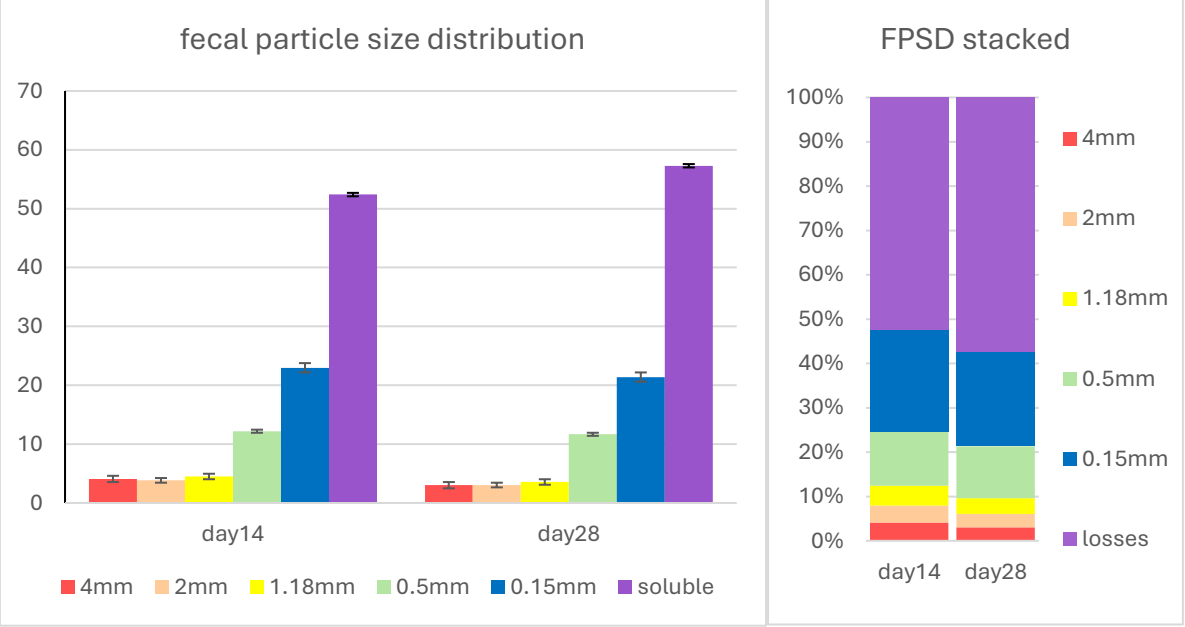

Figure 2. Change in fecal particle size distribution (FPSD) between day 14 and day 28 (combined run 1 and 2), measured using wet sieving, standard error displayed using error bars (left figure). P-values for the effect of day for particles retained on 4 mm; 1.18 mm; 0.15 mm screens and soluble fraction was < 0.05; for particles retained on 2 mm screen was $0.05 < P < 0.1$; for particles retained on 0.5 mm screen was > 0.1 (not statistically relevant)

3.3. Correlations between ruminal pH, fecal pH, and particle size distribution

Correlation analysis revealed associations ($P < 0.01$) between fecal pH and some fractions of particle size. Specifically, the fractions of largest particles and the soluble fraction. Fecal pH had a negative correlation with the > 4 mm particle fraction ($r = -0.329$) and the > 2 mm particle fraction ($r = -0.392$) and positive correlation with the soluble fraction ($r = 0.273$). Correlation between fecal pH and the 1.18 mm; 0.5 mm; and 0.15 mm particle fractions were not significant.

None of the particle size fractions significantly correlated with ruminal pH.

All correlations and their P-value is shown in Table 3.

Table 3. Correlations between fecal particle sizes and fecal/ruminal pH

	Pearson Correlation Coefficients					
	4 mm	2 mm	1.18 mm	0.5 mm	0.15 mm	soluble
Fecal pH	-0.329 P = 0.003	-0.392 P = 0.0004	-0.166 P = 0.14	-0.149 P = 0.19	-0.020 P = 0.86	0.273 P = 0.015
Ruminal pH	-0.111 P = 0.33	-0.101 P = 0.38	-0.027 P = 0.82	-0.069 P = 0.55	0.164 P = 0.15	0.006 P = 0.96

4. Discussion

This study aimed to assess the changes in pH and particle size that happen when the cows are fed high concentrate diets for longer periods of time. Our hypothesis was that we would find that cows adapt to the change in diet over the experimental period, and that some of the parameters would shift towards a healthy condition observed in cows fed with a lower concentrate percentage diet (mean ruminal pH between 6 and 6.5, fecal pH of 7, and a fecal particle size distribution with lower soluble fraction) previously established by other authors (6,10). The results outlined in this study do support this hypothesis, especially fecal pH and to an extent fecal particle size.

Feed that contains high levels of starch via concentrates has a major impact on the microbiome (11,27), fermentation dynamics, and pH(8,28) of not only the rumen but also on hindgut and feces. These effects can have a large impact on health, productivity, and wellbeing of dairy cows. This condition results from increased digesta passage and greater escape of starch from the rumen, which reach the lower gut, where it is rapidly fermented, lowering digesta pH. Therefore, both ruminal acidosis and hindgut acidosis due to increased fermentation in the lower gut may contribute to detrimental effects on gut function, animal health and welfare, and potentially impair production performance. Thus, our results contribute to understand the effects of high-concentrate feeding on hindgut pH and fecal characteristics.

High starch feeding has an immense impact on fecal pH, acidifying the hindgut significantly compared to forage feeding (6,20,21), possibly due to a higher portion of fermentable molecules passing through the rumen (19). Previous research has shown that this condition leads to higher starch contents in the small intestine (29) and, indirectly through the smaller feed particle sizes, shorter mean ruminal retention time (9). We found that the duration of high concentrate feeding did not further lower fecal pH, but rather the opposite. This could be explained by the cows' digestion and gut microbiota adapting to the changed diet over the experimental period, reversing the shift in fermentation site. Especially in this regard, a sampling on day 0 might have been informative, but this was not possible within the framework of this Thesis.

Wet sieving has been established as a valid method for evaluating fecal particle size and assessing nutrient utilization (23). Previous research has shown high concentrate feeding to lead

to more large particles in fresh feces (6) compared to forage diet, indicating compromised fiber breakdown and lower ruminal pH (10,27). We did not see this increase further, but rather the opposite. The 4 mm fraction significantly decreased between day 14 and 28. Even when accounting for the increase in the soluble fraction, there were fewer large particles on day 28.

The decrease in the small particle size fractions (relative to fecal DM) that previous authors have found (6), however, was also found in our experimental period. This can be caused by two different factors. For example, small particles may be selectively retained in the rumen, extending time of exposure (30), and the larger surface area of the small particles may also lead to increased exposure and therefore breakdown (31).

The soluble fraction, meanwhile, can escape the rumen more easily. Adding to this fraction is the products of the fermentation that the larger particles undergo (32,33). Our results show the trend of increasing soluble fraction continuing during extended period of high concentrate feeding. We also saw a correlation between higher fecal pH and higher soluble fraction, which went against expectation. It is possible that the fermentation processes that may cause the increase in the soluble fraction happen mostly in the rumen, and that the proposed reduction in hindgut fermentation on day 28 compared to day 14 has less effect on this fraction.

Overall, changes in particle size distribution during extended time on high-concentrate feed only partially continue the trend set as cows transition from forage diet to high-starch as found by previous authors (6–13).

Another finding that the experiment revealed, is that during the experimental period there was no statistically significant change in rumen pH, despite the changes in fecal pH and fecal particle size distribution. Whether that is due to the 50 % concentrate diet not containing enough starch to push the cows to ruminal acidosis (in fact, of all 78 ruminal pH measurements, only one data point crossed the SARA threshold of <5.8 pH), or if this lack of change would persist even if cows were fed a higher starch diet for the same amount of time will require further research.

Previous research has shown strong correlation between fecal and ruminal pH (6,28) and even found specific thresholds of fecal pH that, if crossed, can be indicators or SARA (6). Our research showed that longer periods of high-concentrate diet can allow some of the fecal

properties to return closer to what they would be with a diet containing less concentrate. This would mean that the threshold to indicate SARA may move as cows adjust to the new diet.

5. Conclusion

We found that more time spent on a high-starch, high concentrate diet has a marked effect on fecal pH and fecal particle size distribution but no significant effect on ruminal pH. Fecal pH rises between week 2 and week 4 while the particle size distribution further shifts to favor the soluble fraction, suggesting that some but not all the changes in fermentation dynamics continue during extended periods of high starch feeding. However, further research will be required due to the differences in feeding and metabolism of lactating versus non-lactating cows and to confirm if these findings can be applied to starch-richer diets or cows fully induced to SARA.

Funding

This study did not receive any specific grants.

Declaration of competing interest

None.

Acknowledgements

We thank the staff at the “vetfarm” research farm of the VetMedUni Wien, and the laboratory technician A. Dockner. We also sincerely thank Dr. R Rivera-Chacon, T Enzinger, and Dr. E. Castillo-Lopez (University of Veterinary Medicine Vienna) for their help.

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