VOL I

Estudos em Ciências Agrárias e Ambientais

Eduardo Spers
(Organizador)

EDITORA ARTEMIS
2024

VOL I

Estudos em Ciências Agrárias e Ambientais

Eduardo Spers
(Organizador)

EDITORA ARTEMIS
2024

Editora Chefe	Profª Drª Antonella Carvalho de Oliveira
Editora Executiva	M.ª Viviane Carvalho Mocellin
Direção de Arte	M.ª Bruna Bejarano
Diagramação	Elisangela Abreu
Organizador	Prof. Dr. Eduardo Eugênio Spers
Imagem da Capa	Bruna Bejarano, Arquivo Pessoal
Bibliotecário	Maurício Amormino Júnior – CRB6/2422

EDITORA ARTEMIS
2024

Editora Artemis
Curitiba-PR Brasil
www.editoraartemis.com.br
e-mail:publicar@editoraartemis.com.br

Editora Artemis
Curitiba-PR Brasil
www.editoraartemis.com.br
e-mail:publicar@editoraartemis.com.br

Dados Internacionais de Catalogação na Publicação (CIP)
(eDOC BRASIL, Belo Horizonte/MG)

E82 Estudos em Ciências Agrárias e Ambientais I [livro eletrônico] / Organizador Eduardo Eugênio Spers. – Curitiba, PR: Artemis, 2024.

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
Edição bilíngue
ISBN 978-65-81701-19-2
DOI 10.37572/EdArt_300724192

1. Ciências agrárias – Pesquisa – Brasil. 2. Meio ambiente. 3.Sustentabilidade. I. Spers, Eduardo Eugênio.

CDD 630

Elaborado por Maurício Amormino Júnior – CRB6/2422

Editora Artemis
Curitiba-PR Brasil
www.editoraartemis.com.br
e-mail:publicar@editoraartemis.com.br

APRESENTAÇÃO

O campo das ciências agrárias e ambientais está em constante evolução, refletindo a necessidade crescente de entender e gerenciar os recursos naturais e a produção agrícola de maneira sustentável.

O primeiro volume desta nova coletânea "**Estudos em Ciências Agrárias e Ambientais"**, reúne 12 capítulos de destacados pesquisadores, oferece uma visão abrangente das investigações mais recentes em quatro eixos cruciais e complementares: ciências agrárias, ciências dos animais, ciências dos alimentos e ciências ambientais.

No eixo **Estudos em Ciências Agrárias**, os artigos exploram a variabilidade genética e os métodos de cultivo que podem influenciar a produtividade e a qualidade das culturas. O estudo da heterose em sementes híbridas de milho azul (cap. 1) revela como características superiores podem ser obtidas por meio de cruzamentos específicos. Adicionalmente, a análise do potencial genotécnico de híbridos e variedades sintéticas de milho azul (cap. 2) demonstra a importância da adaptação regional para maximizar a produtividade. A pesquisa sobre a manipulação de plantas de limão persa (cap. 3) e a propagação vegetativa do lúpulo (cap. 4) trazem insights sobre práticas de cultivo que podem otimizar a produção.

O eixo **Estudos em Ciências dos Animais** foca na saúde e na eficiência dos sistemas de produção animal. A detecção de imunoglobulinas contra *Anaplasma marginale* (cap. 5) é essencial para a compreensão das doenças bovinas, enquanto a avaliação da eficiência do uso de nutrientes em bovinos (cap. 6) pode melhorar a produtividade e a sustentabilidade das operações de pecuária. O estudo sobre a seroprevalência de *Mycobacterium avium* subespécie paratuberculosis em ovinos (cap. 7) oferece informações valiosas para o controle de doenças em sistemas de produção ovina.

Os artigos do terceiro eixo, **Estudos em Ciências dos Alimentos**, discutem a inovação e a funcionalidade na produção de alimentos. O potencial das sementes de *Moringa oleifera* (cap. 8) é explorado, destacando seus benefícios nutricionais e aplicações alimentares. Além disso, a dinâmica do status total de antioxidantes ao longo do processo de produção de vinho (cap. 9) revela como a qualidade do vinho pode ser monitorada e aprimorada, desde o suco até o produto final.

Finalmente, o eixo temático **Estudos em Ciências Ambientais** aborda questões cruciais relacionadas ao meio ambiente e à conservação. A investigação sobre a doença de manchas marrons e suas interações com hospedeiros (cap. 10) oferece uma visão sobre a gestão de doenças em agroecossistemas. Os avanços na conservação dos recursos genéticos de baunilha no México (cap. 11) são discutidos, evidenciando esforços para preservar espécies ameaçadas e a pesquisa sobre macrofauna bentônica em riachos (cap. 12) demonstra a importância dos organismos do solo para a saúde dos ecossistemas aquáticos.

Este livro não só apresenta pesquisas inovadoras e relevantes, mas também promove uma integração de conhecimentos que é vital para enfrentar os desafios contemporâneos nas ciências agrárias e ambientais. Acreditamos que as descobertas aqui compiladas contribuirão significativamente para o avanço da ciência e para a implementação de práticas mais sustentáveis e eficientes.

Desejo a todos uma proveitosa leitura!

Eduardo Eugênio Spers

SUMÁRIO

ESTUDOS EM CIÊNCIAS AGRÁRIAS

ESTUDOS EM CIÊNCIAS DOS ANIMAIS

CAPÍTULO 6

NUTRIENT USE EFFICIENCY EVALUATION OF BEEF CATTLE FEEDLOT

Data de submissão: 20/06/2024
Data de aceite: 04/07/2024

Andrea Wingartz Otaduy
National Autonomous University of Mexico
Veterinary Medicine and Zootechnics
Mexico City, Mexico
https://orcid.org/0000-0003-2791-7954

Rafael Olea Pérez
National Autonomous University of Mexico
Veterinary Medicine and Zootechnics
Mexico City, Mexico
https://orcid.org/0000-0002-5310-0414

José Luis Dávalos Flores
National Autonomous University of Mexico
Veterinary Medicine and Zootechnics
Mexico City, Mexico
https://orcid.org/0000-0003-4524-5207

María Edna Álvarez Sánchez
Autonomous University of Chapingo
Soils and Agriculture
Texcoco, Mexico
https://orcid.org/0000-0001-5484-5269

ABSTRACT: Feedlot's high-intensity operations achieve average daily gains of 1.36-1.9 kg, with peak values up to 2.5 kg. Despite the efficient dietary practices that maximize digestibility and energy, feedlot systems are highly dependent on imported feed, making them susceptible to market fluctuations and posing environmental challenges due to nutrient waste. This study evaluates the Nutrient Use Efficiency (NUE) of Dry Matter (DM), Nitrogen (N), and Phosphorus (P) in a central Mexican feedlot with a maximum capacity of 8,000 animals, aimed at quantifying nutrient retention as live weight gain (LWG). A mass balance methodology was used to assess nutrient inputs and outputs over one year. The results indicated that the NUE was 15% for DM, 17% for N, and 29% for P, with the majority of nutrients lost in feed waste, manure and energy for maintenance. The findings suggest that while improvements in feed management, infrastructure, and genetic and sanitary measures can slightly enhance NUE, substantial gains are limited to about 5%. The most significant opportunity for improving overall NUE and reducing environmental impact lies in revaluing manure as a co-product rather than waste. Effective manure management can retain more nutrients within the system, thereby enhancing the efficiency and sustainability of feedlot operations. This comprehensive assessment underscores the importance of targeted strategies to optimize nutrient use in feedlots, highlighting the potential benefits of treating manure as a valuable resource.

KEYWORDS: Feedlot nitrogen efficiency. Feedlot phosphorus efficiency. Mass balance feedlot.

1 INTRODUCTION

Feedlots are characterized by the high intensity with which liveweight gains are attained, reaching 1.36-1.9 kg of average daily gain (ADG) and up to 2.5 kg (NRC, 2000). Achieving these ADGs requires a series of management practices, the most influential factor has been established to be the dietary composition, providing high digestibility, energy and protein, as well as growth promoters (Berthiaume et al., 2006; Gorocica-Buenfil & Loerch, 2005). To supply these complex diets in the large quantities, feedlots permanently import prime matters, such as grains and forages. Relying entirely on imported feed for production, feedlots are inherently dependent systems, making them susceptible to agricultural and market fluctuations (Cheng et al., 2022). Additional to the vulnerability the dependency confers, feedlots face challenges associated with the environmental impacts generated, mainly arising from the fractions of Dry matter (DM), Nitrogen (N) and Phosphorus (P) that are not retained as weight gain, and therefore result in wasted nutrients (Cheng et al., 2022). DM and N released to the environment contribute to livestock greenhouse gases emissions as nitrous oxides and methane. Conversely, N and P losses affect air quality, generate aquatic and terrestrial acidification and eutrophy marine and freshwater environments (Angelidis et al., 2019). Thereby, assessing the amount of nutrients that are transformed into weight gain and the amount considered waste is important not only to develop dietary management plans to minimize losses, but also to reduce the consequential emissions. The portion of nutrients retained in the end product (weight gain) is commonly referred to as Nutrient Use Efficiency (NUE) (Vaneeckhaute et al., 2014). The NUE is obtained through mass balance assessments, which determine the difference between nutrient inputs and outputs. Mass balance studies are a first approach into the comprehensive analysis of NUE, providing with a quantitative framework to estimate and identify nutrient flows (Homolka et al., 2021). This methodology has been widely applied in the agricultural sector, and feedlot productions, since it has proven to be simple, flexible and an affordable tool in the pursuit towards more efficient production (Luebbe et al., 2012; Rout & Behera, 2021).

Feedlot management practices vary significantly in terms of feeding ingredients, quantities, geographical region, breed, and other factors. Consequently, developing a mass balance for the specific feedlot targeted for improvement is essential. The aim of the present study was to estimate the NUE of DM, N and P in a specific feedlot and to quantify the portions of each nutrient that are not utilized and thus contribute to emissions.

2 MATERIALS & METHODS

A feedlot mass balance was conducted, evaluating the DM, N and P inputs and outputs for one year of operation. The feedlot assessed as a case study was located in central Mexico, where the mean annual temperature is 17 °C (3.4°C min. -31.2°C max.), mean annual precipitation 700mm, and evapotranspiration potential 1,600mm. The feedlot had a maximum capacity for 8,000 animals, and the fattening cycle consisted of six consecutive phases (Table 1), presenting an average initial weight of 240±50 kg and average final weight of 577±24 kg. After reaching final weight, the animals were sold as live cattle at farm´s gate.

Upon reception, every animal was subject to the sanitary protocol including veterinary evaluation, vaccination, deworming, implantation and medical treatment if necessary.

Table 1. Productivity parameters obtained through farm data analysis corresponding to one year´s activity; presented by fattening phase.

	Unit	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6*
Average weight	Kg	240 ± 50	266 ± 37	352 ± 53	429 ± 20	479 ± 31	542 ± 36
Duration	Days	7.2 ± 3.6	47±22.9	62±16.1	33±9.0	46±6.4	35±6.7
Average daily weight gain	Kg	0.44	1.6 ± 0.34	1.7 ± 0.45	1.2 ± 0.41	1.4 ± 0.38	1.85 ± 0.32
DM intake per animal	Kg day^{-1}	4.5	6.7	8.2	9.6	9.7	10.5
ME intake per animal	Mcal day^{-1}	9.5	11.8	15	23	27	29
Crude protein intake	% of DM	9	11	13	13.25	12.5	13
Phosphorus intake	% of DM	0.6	0.45	0.25	0.3	0.3	0.3

Where: ME= Metabolizable Energy, DM= Dry matter.
* Inclusion of Zilpaterol.

We considered tones of liveweight (LW) gain as the only product obtained from the process, stating that manure (the sum of feces and urine), feed waste, and mortalities were not included as co-products, nor included in the NUE, since these resources were not sold or applied as an asset to the system. The spatial boundaries were set to initiate with feed and livestock inputs, and encompass as far as livestock, manure, feed waste and mortalities as outputs. To conduct the calculations, the model detailed in Equation 1 was applied:

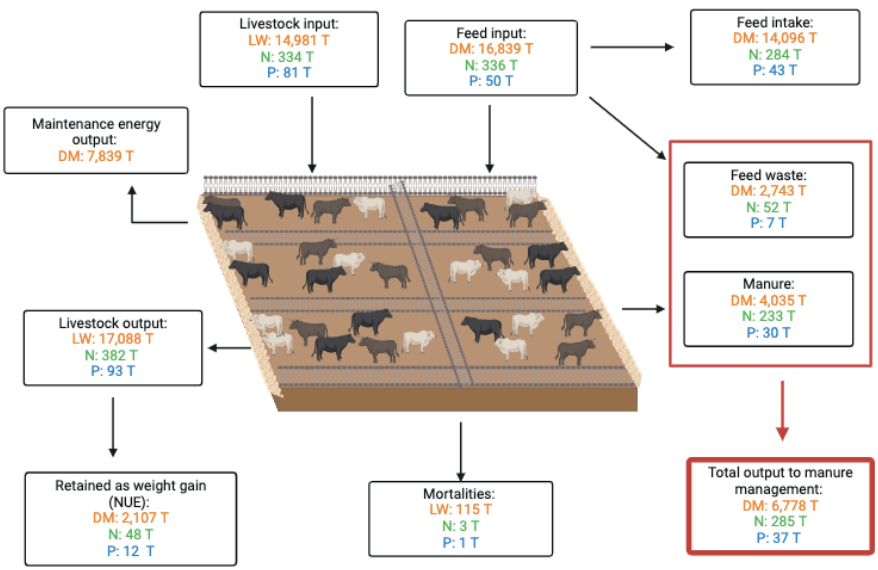
Equation 1. Mathematical model used to determine NUE (tones). Where: *X* = amount of nutrient, *if* = input as feed, *ilw* = input as liveweight, *omt* = output as mortalities, *omet* = output through nutrient metabolization, *owas* = output as feed waste and *om* = output as manure.

$$X_{NUE} = \Sigma\,[X_{if} + X_{ilw} - X_{omt} - X_{omet} - X_{owas} - X_{om}]$$

3 RESULTS AND DISCUSSION

Initial results are presented considering overall livestock and feed inputs, regardless of feed being consumed or dispatched as waste. For this matter, nutrients flows are presented in Figure 1, showing total inputs of 14,981 tones of LW, 16,839 tones of DM, 670 tones of N and 131 tones of P. The NUE for DM was only 13%, 15% for N and 24% for P, achieving a total LW gain of 2,107 tones. Tracking nutrient losses, we can determine that the largest output was attained by the compound of feed waste and manure, which represented 40% of the total DM that entered the system, 85% of total N and 74% of total P. This compound constitutes the prime matter that will enter the respective manure management system, a process that falls outside the scope of the present study. Another significant finding, is the loss of nutrients through feed waste, representing 16% of DM, 15% of N and 14% of P that entered the system, which is directly related to inadequate infrastructure and sub-optimal feed management practices. Considering the previous statement results were analyzed excluding feed waste parameters, providing insight only for the fraction of feed that was consumed.

Figure 1. Feedlot nutrient flow. Results of inputs and outputs for one year. Where: T= Tones, LW = Live weight, DM = Dry matter, N = Nitrogen, P = Phosphorus and NUE = nutrient use efficiency.



When nutrients corresponding to feed intake were considered as 100%, the NUE for DM was 15% (Figure 2). For this category, the primary output was the fraction of DM consumed as energy for maintenance (56%). Table 2 provides reference values from a standardized source, indicating that 58% of dry matter intake (DMI) is allocated to energy consumption for maintenance (ASAE, 2005). According to the NRC (2000) the two most influential factors affecting this allocation are genetics and mean environmental temperature, but even under optimal conditions, the allocation does not fall below 53%.

Figure 2. Distribution of dry matter intake allocated to corresponding output.

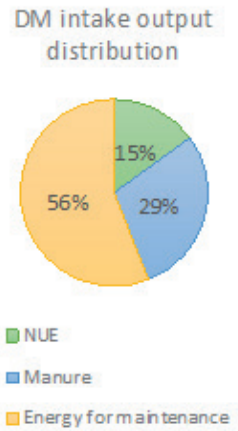


Figure 3. Distribution of nitrogen intake allocated to corresponding output.

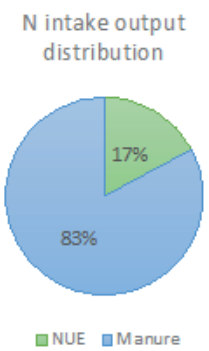
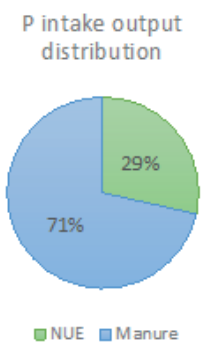


Figure 4. Distribution of phosphorus intake allocated to corresponding output.



As for N, NUE was 17% and 83% was excreted in manure (Figure 3), differing by only 2% from the reference values (Table 2). The percentage of nitrogen excreted increases with higher N intake (Luebbe et al., 2012). This was confirmed in a study where the crude protein (CP) content of the diet was raised from 13% to 17%, resulting in an increase in the excretion rate from 82% to 89% (Luebbe et al., 2012). More recent findings by Homolka et al. (2021) support this, showing that even with smaller increments in CP, from 14.4 to 16%, excretion increased from 86.5 to 87.5%. Studies consistently indicate that increasing dietary CP beyond 13.5% does not enhance live weight gain, but rather increases nitrogen excretion in manure (Homolka et al., 2021b; Luebbe et al., 2012; NRC, 2000).

For P the NUE was 29%, with 71% excreted (Figure 4), indicating a higher retention rate than the reference value (Table 2). The increased NUE may be related to the use of a more digestible P source in the present study, although this proposition cannot be conclusively validated due to insufficient information from the reference values. Similar to N, P excretion rises with increased intake. Authors observed that increasing P content in

DM from 0.33% to 0.49 resulted in an increase in P excretion from 73% to 81% (Luebbe et al., 2012). When the increment was from 0.32% to 0.33% excretion shifted from 79.8% to 80.7%, suggesting that a 0.01% increase in intake leads to a 1% increase in excretion. However, this relationship requires further measurements for validation (Homolka et al., 2021). The optimal intake range for P as a percentage of DM is 0.30%-0.35%; values exceeding this range result in wastage, thereby increasing the excretion percentage.

For feedlots under similar characteristics as the subject of this study, which provide high digestibility diets (>75%), include growth promoters and anabolic implants, the NUE has a low improvement margin (NRC, 2000). Regardless of the NUE, it is inevitable that the majority of the nutrients will ultimately end up in manure.

Table 2. Results of NUE and excretion rates for the present study and the corresponding reference values from a standardized source (ASAE, 2005). Where: DM = Dry matter, N = Nitrogen, P = Phosphorus, DMI = Dry matter intake, NUE = Nutrient use efficiency, CP = Crude protein, EM = Energy for maintenance, NI = Nitrogen intake, PI = Phosphorus intake.

Nutrient	Parameter	Present study	Reference values	Source
DM	DMI consumed for EM	56%	58%	(ASAE, 2005)
	NUE	15%	16%	
	DMI excreted in manure	29%	26%	
N	CP in DM	12.4%	13.4%	
	NUE	17%	15%	
	NI excreted in manure	83%	85%	
P	P in DM	0.32%	0.31%	
	NUE	29%	21.4%	
	PI excreted in manure	71%	78.6%	

4 CONCLUSIONS

Improving NUE in feedlots should be addressed with a comprehensive approach. Implementing adequate management practices and infrastructure to reduce feed waste, providing shade, ensuring optimal nutrient requirements and digestibility, and enhancing genetics and sanitary measures can positively influence NUE. However, feedlots similar to the one evaluated in this study are unlikely to achieve improvements greater than 5% in any of the evaluated categories (Homolka et al., 2021b; Larney & Hao, 2007; Luebbe et al., 2012; NRC, 2000). The most significant opportunity to optimize NUE lies in recognizing manure as a valuable resource. By improving manure management to enhance nutrient retention and shifting the perception of manure from waste to co-product, substantial improvements can be made in the overall production system´s NUE and environmental burdens.

5 ACNOWLEDGEMENTS

We extend our gratitude to the Mexican National Council of Humanities, Science and Technology (CONAHCYT) for the grant given to the primary author to conduct this study. Additionally, we thank the National Autonomous University of Mexico for being the institution where the research took part. Lastly, we acknowledge and value the collaboration of Nutryplus SAPI de CV whose involvement served as the link between our team and the subject of our study.

REFERENCES

Angelidis, A., Crompton, L., Misselbrook, T., Yan, T., Reynolds, C. K., & Stergiadis, S. (2019). Evaluation and prediction of nitrogen use efficiency and outputs in faeces and urine in beef cattle. *Agriculture, Ecosystems and Environment*, *280*(April), 1–15. https://doi.org/10.1016/j.agee.2019.04.013

ASAE. (2005). Manure production and characteristics. *American Society of Agriclutural Engineer*s, 4.

Berthiaume, R., Mandell, I., Faucitano, L., & Lafrenière, C. (2006). Comparison of alternative beef production systems based on forage finishing or grain-forage diets with or without growth promotants: 1. Feedlot performance, carcass quality, and production costs. *Journal of Animal Science*, *84*(8), 2168–2177. https://doi.org/10.2527/jas.2005-328

Cheng, M., McCarl, B., & Fei, C. (2022). Climate Change and Livestock Production: A Literature Review. *Atmosphere*, *13*(1). https://doi.org/10.3390/atmos13010140

Gorocica-Buenfil, M. A., & Loerch, S. C. (2005). Effect of cattle age, forage level, and corn processing on diet digestibility and feedlot performance. *Journal of Animal Science*, *83*(3), 705–714. https://doi.org/10.2527/2005.833705x

Homolka, M. N., Erickson, G. E., & Koelsch, R. K. (2021). *Predicting nitrogen and phosphorus balance in beef open lots*. *2010*, 641–653.

Larney, F. J., & Hao, X. (2007). A review of composting as a management alternative for beef cattle feedlot manure in southern Alberta, Canada. *Bioresource Technology*, *98*(17), 3221–3227. https://doi.org/10.1016/j.biortech.2006.07.005

Luebbe, M. K., Erickson, G. E., Klopfenstein, T. J., & Greenquist, M. A. (2012). Nutrient mass balance and performance of feedlot cattle fed corn wet distillers grains plus solubles. *Journal of Animal Science*, *90*(1), 296–306. https://doi.org/10.2527/jas.2009-2414

National Research Council. (2000). Nutrient Requirements of Beef Cattle: Seventh Revised Edition: Update 2000. In *Nutrient Requirements of Beef Cattle* (Vol. 2000). https://doi.org/10.17226/9791

Rout, P. K., & Behera, B. K. (2021). Sustainability in Ruminant Livestock: Management and Marketing. In *Sustainability in Ruminant Livestock: Management and Marketing*. https://doi.org/10.1007/978-981-33-4343-6

Vaneeckhaute, C., Ghekiere, G., Michels, E., Vanrolleghem, P. A., Tack, F. M. G., & Meers, E. (2014). Assessing Nutrient Use Efficiency and Environmental Pressure of Macronutrients in Biobased Mineral Fertilizers: A Review of Recent Advances and Best Practices at Field Scale. *Advances in Agronomy*, *128*, 137–180. https://doi.org/10.1016/B978-0-12-802139-2.00004-4

SOBRE O ORGANIZADOR

EDUARDO EUGENIO SPERS realizou pós-doutorado na Wageningen University (WUR), Holanda, e especialização no IGIA, França. Possui doutorado em Administração pela Universidade de São Paulo (USP). Foi Professor do Programa de Mestrado e Doutorado em Administração e do Mestrado Profissional em Comportamento do Consumidor da ESPM. Líder do tema Teoria, Epistemologia e Métodos de Pesquisa em Marketing na Associação Nacional de Pós-Graduação e Pesquisa em Administração (ANPAD). Participou de diversos projetos de consultoria e pesquisa coordenados pelo PENSA e Markestrat. É Professor Titular no Departamento de Economia, Administração e Sociologia, docente do Mestrado em Administração e Coordenador do Grupo de Extensão MarkEsalq no campus da USP/Esalq. Proferiu palestras em diversos eventos acadêmicos e profissionais, com diversos artigos publicados em periódicos nacionais e internacionais, livros e capítulos de livros sobre agronegócios, com foco no marketing e no comportamento do produtor rural e do consumidor de alimentos.

ÍNDICE REMISSIVO

V

Z