

Atendendo solicitação do(a) autor(a), o texto completo desta tese/dissertação será disponibilizado somente a partir de 25/01/2023

At the author's request, the full text of this thesis / dissertation will not be available online until January 25, 2023

UNIVERSIDADE ESTADUAL PAULISTA
FACULDADE DE MEDICINA VETERINÁRIA E ZOOTECNIA
CAMPUS BOTUCATU

CARACTERIZAÇÃO DA COMUNIDADE MICROBIANA E PADRÃO DA
FERMENTAÇÃO RUMINAL DE BOVINOS ANGUS E NELLORE DURANTE A
ADAPTAÇÃO A DIETAS COM ALTO TEOR DE ENERGIA COM DIFERENTES
ESTRATÉGIAS NUTRICIONAIS

ANA CAROLINA JANSSEN PINTO

Tese apresentada ao Programa de
Pós-Graduação em Zootecnia como parte
das exigências para obtenção do título de
Doutor em Zootecnia

BOTUCATU- SP
JAN/ 2022

SAO PAULO STATE UNIVERSITY
FACULTY OF VETERINARY MEDICINE AND ANIMAL SCIENCE
BOTUCATU CAMPUS

CHARACTERIZATION OF THE MICROBIAL COMMUNITY AND PATTERN OF
RUMINAL FERMENTATION OF ANGUS AND NELLORE CATTLE DURING
ADAPTATION TO DIETS WITH HIGH ENERGY CONTENT WITH DIFFERENT
NUTRITIONAL STRATEGIES

ANA CAROLINA JANSSEN PINTO

Advisor: Danilo Domingues Millen

Thesis presented to the Graduate
Program in Animal Science as part of the
requirements for obtaining the title of
Doctor in Animal Science

BOTUCATU- SP
JAN/ 2022

- P659c Pinto, Ana Carolina Janssen
Caracterização da comunidade microbiana e padrão da fermentação ruminal de bovinos angus e nellore durante a adaptação a dietas com alto teor de energia com diferentes estratégias nutricionais / Ana Carolina Janssen Pinto. -- Botucatu, 2022
98 p. : il., tabs.
- Tese (doutorado) - Universidade Estadual Paulista (Unesp), Faculdade de Medicina Veterinária e Zootecnia, Botucatu
Orientador: Danilo Domingues Millen
1. Metabolismo. 2. Microrganismos. 3. Angus. 4. Nellore. 5. Confinamento. I. Título.

AUTHOR`S BIOGRAPHY

Ana Carolina Janssen Pinto was born in the city of São Paulo, SP, Brazil, on February 10, 1985. She attended elementary and high school at Colégio Visconde de Porto Seguro Unit I, in the city of São Paulo, concluding it in 2003. In August 2011, she began her degree in Animal Science at the Sao Paulo State University “Júlio de Mesquita Filho”, Dracena Campus, concluding in January 2016. During the undergraduate course, she received a scholarship from the Fundação de Amparo à Pesquisa do Estado de São Paulo - FAPESP, and she was a BEPE Research Internship Scholar at the University of Saskatchewan, Saskatoon, Canada. In March 2016, she started the Master's degree in Animal Science and Technology in the inter-unit program of the Ilha Solteira and Dracena campus of UNESP where she obtained the Master's degree in Animal Science and Technology in December 2017. During the Master's course, she received a scholarship from the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP). She was also a fellow of the BEPE research internship abroad at the University of Pennsylvania, State College, United States. In March 2018, she started her Doctoral course at the Faculty of Veterinary Medicine and Animal Science (Unesp Botucatu) and received a scholarship from the Fundação de Amparo à Pesquisa do Estado de São Paulo - FAPESP. She had a scholarship to the University of Wisconsin, but with the pandemic Covid-19, she could not complete the internship. She works in the area of Nutrition and the production of beef cattle.

DEDICATION

To my father and my best friend José Neudson (im), who even not present in this carnal world, has always guided me, enlightened me and wanted my steps. He has always gone out of his way for anything and has always been and will be the person who taught me what it is like to love the profession. Besides, he is the reason I open my eyes every morning.

To my immaculate mother Karen and my godparents, Wileina and Peter, for their belief in me, for the education they gave me, for always going out of their ways in my needs, for helping me emotionally, and especially for reaching out whenever the world seemed to collapse.

ACKNOWLEDGEMENTS

First, I thank God for the gift of life and for always giving me health every day that I get up in this earthly life.

To my parents, who always taught me to walk with my own feet, told me that I was capable and taught me: “Carol, if life gives you a lemon, make a tasty lemonade and drink it smiling”. Thank you for making my life lighter and happier. And thank you to teach me, always, that knowledge and family are the greatest and riches in the world. You are my foundation.

To my godparents Wileina and Peter who helped me make life's lemonade. Life plays tricks on us, and without a doubt, you two are the best characters in my new/old play. If I am here today, I owe it all to you.

To my brothers, Xandi, Luca, and brothers-in-law Tássia and Jefferson, thank you for every piece of advice and every reprimand. Thank you for showing me that together we always get somewhere better. To my family who always understood my physical absence from family gatherings.

To Bia, who doesn't know what life is, but made it reborn in me. Thank you for the unconditional love.

To my Zé Maneco, Nicolas, who made this year and the completion of this thesis possible, giving me energy with wide smiles and breastfeeding at dawn. And also to my cousin Gordinha, for always being my sister and who gave me my precious gift (Nicolas).

To my fiancée Gustavo. First, for being my companion on this journey of life, and never giving up on our love, even with adversity. Second, for being my partner in this journey and for always pushing me up.

To my friend and advisor Danilo Millen, who guided me along paths I had never seen before, flourishing and illuminating my professional and personal trajectory. In addition, I thank you for the trust, encouragement, friendship, and opportunity you have always given me.

To my friend Mariana Squizatti that helped me even when she mustn't to be there. I'll always be thankful for your friendship and your support for all these years. You gave me help, laugh and a house!!!

To Antonio Silvestre, Tonhao, thank you for supporting me with this experiment, thank you for making me see beyond my glasses even in a feedlot.

To the team from the Rumenology lab who were my feet, hands, and head in conducting this experiment. Thank you for every collection period, every smile of good morning, every stress, every laugh, and every help. Without you, it would have been much more difficult and tough to conduct this experiment. Thank you Wrap, Geisy, Lidi, Resto, Vitor Machado, Mackek, Velma and Thaiano.

To Flávio Perna Júnior who helped me with my tireless doubts during these years. Thank you for every message and phone call answered.

To the animal scientists I look up to, and if one day I am a little bit of who you are, I will be more than fulfilled: Daniel Watanabe, Murillo Stefano, Murilo Chuba, Diego Piovezan, Cassiele Aparecida, Daniel Vicari, and André Nagatani.

To Dunha and Alice for helping me to finish this thesis. Probably it wouldn't be finished if weren't you two.

To my psychologist Thamires, you made me to discovered me myself and I. Since last year I am a better person because you guide me to find myself again! And I did it, and it was amazing. Without you I wouldn't finish this thesis too.

For all ADHD person, who aren't self-confidence, who can't write so well, who can't be focused and organized as much as should be, who can talk to everything around. This is for us, for everyone to know that we faced difficulties but we reached to the end. This is just a reminder for me and for whom it serves, I am not laziness. I DID IT.

To Prof Garret Suen for accepting my visit to the laboratory (I did not do it because of COVID) and especially for the sequencing analyses performed in his laboratory.

To all field assistants from Unesp Dracena-FCAT (Adriano, João Paulo, Fábio, Zé Nilton) who helped and allowed this experiment to be carried out.

To Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), for the pHd scholarship granted (process nº 2018/17983-0) who were fundamental for the entire development of my doctorate and personal growth.

This work was carried out with the support of the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código de Financiamento 001.

To all who were not mentioned here and who contributed in some way to the realization of this research.

“Mas é preciso ter força, é preciso ter raça
É preciso ter gana sempre
Quem traz no corpo a marca, Maria, Maria
Mistura a dor e a alegria
Mas é preciso ter manha, é preciso ter graça
É preciso ter sonho sempre
Quem traz na pele essa marca possui
A estranha mania de ter fé na vida...”

Maria, maria
(Milton Nascimento)

RESUMO GERAL

RESUMO: O objetivo deste estudo foi avaliar o efeito de diferentes estratégias nutricionais durante o período de adaptação e terminação sobre a fermentação ruminal e comunidade microbiana ruminal de bovinos Angus e Nelore canulados confinados. Foram utilizados 4 bovinos da raça Nelore e 4 bovinos da raça Angus, castrados, com peso vivo inicial aproximado de 450 kg e canulados no rúmen, os quais foram divididos em dois quadrados latinos 4 x 4 contemporâneos, sendo que cada quadrado foi composto por animais de mesma raça. Os períodos foram divididos em: 14 dias de dieta de adaptação (5 dias de adaptação 1- 65% de concentrado, 4 dias de adaptação 2- 70% de concentrado e 5 dias de adaptação 3- 75% de concentrado) e 18 dias de dieta de terminação (80% de concentrado). As dietas fornecidas diferenciavam apenas no tocante ao processamento dos grãos de milho e pela presença ou não monensina sódica. Portanto, os tratamentos ocorreram da seguinte maneira: MF(+)- Milho moído fino + monensina (27ppm); MF(-)- Milho moído fino MU(+)- Milho grão úmido + monensina (27ppm) e MU(-)- Milho grão úmido. A duração deste estudo foi de 158 dias, sendo compostos por 4 períodos experimentais (32 dias cada período) e três intervalos de *washout* (7 dias) entre os períodos 1 e 2, 2 e 3 e 3 e 4. Os Angus tiveram maior IMS nos dias 12 e 16 quando comparado aos Nelores ($P=0.02$). Os Angus também tiveram o pH médio menor e maior temperatura ruminal que a raça Nelore. Os animais Nelore tiveram maior diversidade Shannon que os Angus ($P=0.007$). Além disso, a raça Nelore teve uma maior comunidade dos microrganismos *Butyrivibrio*, *Clostridiales* e *Prevotella* ($P<0.01$) que o Angus. Durante a transição da dieta de adaptação para a de terminação, os animais Angus tiveram um padrão da fermentação ruminal e a comunidade bacteriana diferentes dos animais da raça Nelore.

Palavras-chave: metabolismo, microrganismos, Angus, Nelore

ABSTRACT

The objective of this study was to evaluate the effect of different nutritional strategies during the adaptation and finishing period on ruminal fermentation patterns and microbial community of cannulated Angus and Nellore cattle. Four 30-mo-old Nellore and four 30-mo-old Angus steers were used, with an initial body weight of approximately 450 kg which was divided into two 4 x 4 Latin squares. Each square was composed of animals of the same breed. The periods were divided as follows: 14 days of adaptation diet (5 days of adaptation 1 - 65% concentrate, four adaptation days; 2 - 70% concentrate and five adaptation days; 3 - 75% concentrate) and 18 days of finishing diet (80% concentrate). The diets provided differed only concerning the corn grain processing method and the presence or absence of sodium monensin. The treatments were as follows: FG(+)- Finely ground corn + monensin (27ppm); FG(-)- Finely ground corn HM(+)- High moisture corn + monensin (27ppm) HM(-)-High moisture corn. The study lasted 158 days, in which animals were submitted to four experimental periods (32 days each one) and three washout intervals (7 days) between periods 1 and 2, 2 and 3, and 3 and 4. Angus had higher consumption on days 12 and 16 when compared to Nellore ($P=0.02$). Angus cattle the lowest pH and the higher ruminal temperatures. Nellore breed had higher Shannon diversity than ($P=0.007$). Nellore showed a higher community of *Butyrivibrio*, *Clostridiales* and *Prevotella* ($P<0.01$) than Angus. During the transition period ruminal fermentation pattern and bacteria community are different for Angus than Nellore cattle.

Keywords: metabolism, microorganism, Angus, Nellore

FIGURE LIST

- Figure 1.** Description of the corn grain structure.19
- Figure 3.** Interaction between corn processing type and monensin on eating time (A; SEM = 13.76), average time per meal (B; SEM = 2.08), DMI per meal (C; SEM = 0.13), NDF intake (D; SEM = 0.35) and fine particles selection (E; SEM = 0,01) during the transition phase of canulated Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin; MF(+): finely ground with MON; MF(-): finely ground without MON; MU(+): High-moisture with MON; MU(-): High-moisture without MON; ^{a,b} Different letters differ significantly among treatments.39
- Figure 4.** Treatments interaction between breed factor and corn processing type (A; SEM = 1.60) and effect of breed factor and monensin addition (B; SEM = 1.60) on goings to drinkings fountains during the transition phase of Angus and Nellore bulls fed with with finely ground corn or high-moisture corn with addition or not of monensin; A_MF: Angus fed with finely ground corn; A_MU: Angus fed with high-moisture corn; N_MF: Nellore fed with finely ground corn; N_MU: Nellore fed with high-moisture corn. A(+): Angus supplemented with monensin; A(-): Angus without monensin supplementation; N(+): Nellore supplemented with monensin; N(-): Nellore without monensin supplementation .^{a,b} different letters differ significantly among treatments.40
- Figure 5.** Effect of the corn processing type (A; SEM = 1.26) and MON inclusion (B; SEM = 1.26) on the DMI (kg) of Angus and Nellore bulls fed with with finely ground corn or high-moisture corn with addition or not of monensin during the transition phase. MU: high-moisture corn; MF: finely ground corn. (-): Absence of monensin; (+): Presence of monensin.41
- Figure 6.** Effect of corn processing type on the DM ruminating efficiency (A; SEM = 3.12), and NDF ruminating efficiency (B; SEM = 15.87) during the transition phase of Angus and Nellore bulls fed with different nutritional strategies. HM: high-moisture corn; FG: finely ground corn. Effect of monensins supplementation on NDF eating efficiency (C; SEM = 14.49), of of Angus and Nellore bulls fed with different nutritional strategies during the transition phase. MU: high-moisture corn; MF: finely ground corn; (-): Absence of monensin; (+): Presence of monensin.41
- Figure 7:** Effect of corn processing type (A; SEM = 0.90), and MON supplementation (B; SEM = 0.90) on the number of meals during the finishing phase of Angus and Nellore bulls fed with different nutritional strategies. MU: high-moisture corn; MF: finely ground corn. Interaction between treatments, corn factor and MON factor (C; SEM = 1.52) on the average time per meal during the finishing phase of Angus and Nellore bulls fed with different nutritional strategies. : MF(+): finely ground with MON; MF(-): finely ground without MON; MU(+): High-moisture with MON; MU(-): High-moisture without MON; ^{a,b} Different letters differ significantly among treatments.44

Figure 8. Effect of corn processing type on NDF eating efficiency (**A**; SEM = 17.66), NDF ruminating efficiency (**B**; SEM = 25.17) and NDF intake (**C**; SEM = 0.40) during the finishing phase of Angus and Nellore canulated bulls fed with different nutritional strategies. Mu: high-moisture corn; MF: finely ground corn. 45

Figure 9: Effect of corn processing type (**A**; SEM = 0.006), breed (**B**; SEM = 0.006) and Mon supplementation (**C**; SEM = 0.006) on Particle sorting of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin during the finishing phase. MF: finely ground; MU: High-moisture; A(+): angus supplemented with Mon; A(-): angus non supplemented with Mon ; N(+): Nellore supplemented with Mon; N(-) Nellore non supplemented with Mon. ^{a,b}: different letters differ significantly among treatments..... 46

Figure 10. Interaction between breed and collection day (**A**; SEM = 1.06) and Mon supplementation (**B**; SEM = 13.72) on the DMI of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with additions of monensin or not. ^{a,b,c,d,e,f} Different letters differ significantly among treatments. 49

Figure 11. Interaction between breed and corn processing type on pH área bellow 6.2 (**A**; SEM = 122.41), pH area bellow 5.6 (**B**; SEM = 44.26), pH area bellow 5.2 (**C**; SEM = 28,94), time of pH bellow 5.6 (**D**; SEM = 85.92) and time of pH bellow 5.2 (**E**; SEM = 45.80) of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin. Interaction between breed factor and Mon inclusion on medium pH (**F**; SEM = 0.18) of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin. ^{a,b}: Mean with different letters differ significantly. A(-): Angus non supplemented with MON; A(+): Angus supplemented with MON; N(+): Nellore supplemented with MON; N(-): Nellore non supplemented with MON; A_MF: Angus fed with finely ground corn; A_MU: Angus fed with high-moisture corn; N_MF: Nellore fed with finely ground corn; N_MU: Nellore fed with high-moisture corn..... 50

Figure 12: Interaction between breed fator and diet collection day factor on time of pH bellow 5.6 **A**; SEM = 98.40) and rumen temperature (**B**; SEM = 0.10) of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin. ^{a,b,c,d}: mean with different letters differ significantly. 51

Figure 13. Interaction between breed fator and time after feeding on rumen acetate concentration (**A**; SEM = 3.00), propionate (**B**; SEM = 1.77), lactate (**C**; SEM = 0.002), ammonia (N-NH₃) (**D**; SEM = 3.30) and total SCFA (**E**; SEM = 5.61) of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 4th experimental day. ^{a,b,c,d}: mean with different letters differ significantly. 53

Figure 14: Interaction between breed factor and inclusion or not of MON on the propionate concentration (**A**; SEM = 1.77) and total SCFA (**B**; SEM = 5.32) of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 4th experimental day. Interaction between breed factor, inclusion or not of MON and times after feeding on the butyrate concentration (**C**; SEM = 1.05) of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 4th experimental day. ^{a,b,c,d} mean with different letters differ significantly..

A(-): Angus non supplemented with MON; A(+): Angus supplemented with MON; N(+): Nellore supplemented with MON; N(-): Nellore non supplemented with MON.....54

Figure 15. Interaction between breed factor and time after feeding on rumen acetate concentration (**A**; SEM = 5.79), propionate (**B**; SEM = 2,10) and butyrate (**C**; SEM = 1.69) of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 8th experimental day. Effect of breed factor on rumen lactate concentration (**D**; SEM = 0.002) on 8th experimental day. ^{a,b,c} mean with different letters differ significantly.....58

Figure 16: Effect of breed factor on rumen propionate concentration (**A**; SEM = 2.3) and ammonia (**B**; SEM = 4.49) of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 12th experimental day. Interaction of breed factor, inclusion or not of MON and time after feeding on rumen lactate concentration (**C**; SEM = 1.72) on 12th experimental day. ^{a, b, c, e, f, g, h, i}: Mean with different letters differ significantly. A(-): Angus non supplemented MON; A(+): Angus supplemented with MON; N(+): Nellore supplemented with MON; N(-): Nellore non supplemented MON; A_MF: Angus fed with finely ground corn; A_MU: Angus fed with high-moisture corn; N_MF: Nellore fed with finely ground corn; N_MU: Nellore fed with high-moisture corn.....61

Figure 17: Interaction of breed factor and corn processing type on the butyrate concentration (**A**; SEM = 1.72) and breed factor and time after feeding on lactate concentration (**B**; SEM = 0.04) on day 16 of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 16th experimental day. ^{a,b,c,d,e} Mean with different letters differ significantly. A_MF: Angus fed with finely ground corn; A_MU: Angus fed with high-moisture corn; N_MF: Nellore fed with finely ground corn; N_MU: Nellore fed with high-moisture corn.....63

Figure 18: Interaction between breed factor and time after feeding on rumen lactate concentration (**A**; SEM = 0.04) and ammonia (**B**; SEM = 2.34) of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 20th experimental day. ^{a,b,c,d} Mean with different letters differ significantly.65

Figure 19: Interaction between breed factor and time after feeding on rumen propionate concentration of Angus and Nellore canulated bulls fed with finely ground corn or high-moisture corn with addition or not

of monensin on 24th experimental day. ^{a,b,c,d} Mean with different letters differ significantly ($P = 0.04$) (SEM=2.40). 67

Figure 20: Interaction between breed factor and time after feeding on rumen acetate concentration (**A**; SEM = 3.37), butyrate (**B**; SEM = 0.81) and total SCFA (**C**; SEM = 5.25) of Angus and Nellore castrated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 28th experimental day. ^{a,b,c,d} Mean with different letters differ significantly. 69

Figure 21: Interaction between breed factor and corn processing type on rumen acetate concentration (**A**; SEM = 3.09) and total SCFA (**B**; SEM = 4.79) of Angus and Nellore castrated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 28th experimental day. ^{a,b}: Mean with different letters differ significantly. A_MF: Angus fed with finely ground corn; A_MU: Angus fed with high-moisture corn; N_MF: Nellore fed with finely ground corn; N_MU: Nellore fed with high-moisture corn. 70

Figure 22: Interaction between breed factor and MON supplementation on DM degradability at 2% passage rate (**A**; SEM = 1.20), DM potential degradability (**B**; SEM = 1.12), NDF effective degradability at 5% passage rate (**C**; SEM = 1.56), NDF effective degradability at 2% passage rate (**D**; SEM = 2.49), NDF potential degradability (**E**; SEM = 7.19), ADF potential degradability (**F**; SEM = 1.44) and CP potential degradability (**G**; SEM = 0.91). ^{a,b}: Mean with different letters differ significantly. A(-): Angus non supplemented with Mon; A(+): Angus supplemented with Mon; N(+): Nellore supplemented with Mon; N(-): Nellore non supplemented with Mon. 73

Figure 23: Effect of monensin factor on DM effective degradability at 5% passage rate (**A**; SEM = 1.13), Starch effective degradability at 8% passage rate (**B**; SEM = 1.70), Starch effective degradability at 5% passage rate (**C**; SEM = 1.48) and Starch effective degradability at 2% passage rate (**D**; SEM = 1.48). ... 74

Figure 24: Interaction between breed factor and corn processing type on DM degradability at 8% passage rate (**A**; SEM = 1.33), ADF effective degradability at 8% passage rate (**B**; SEM = 1.34) and ADF effective degradability at 5% passage rate (**C**; SEM = 1.38). ^{a,b}: Mean with different letters differ significantly. A_MF: Angus fed with finely ground corn; A_MU: Angus fed with high-moisture corn; N_MF –Nellore fed with finely ground corn; N_MU: Nellore fed with high-moisture corn. 75

Figure 25. Effect of corn processing type on DM potential degradability (**A**; SEM = 0.94) and NDF degradability potential (**B**; SEM = 5.51). MF: final ground corn; MU: high-moisture corn. 75

Figure 26: Effect of breed factor on CP degradability at 2% passage rate (**A**; SEM = 1.90) CP degradability at 5% passage rate (**B**; SEM = 1.86), CP degradability at 8% passage rate (**C**; SEM = 1.50). A- Angus; N- Nellore. 76

Figure 27: Effect of corn processing type on DM digestibility (**A**; SEM = 0.89), OM digestibility (**B**; SEM = 0.67) and Starch digestibility (**C**; SEM = 1.05) of Angus and Nellore castrated bulls fed with finely

ground corn or high-moisture corn with addition or not of monensin during the finishing phase. MF: finely ground corn; MU: high-moisture corn.	78
Figure 28: Effect of monensin factor on NDF digestibility (A; SEM = 2.54), ADF digestibility (B; SEM = 4.40) and Starch digestibility (C; SEM = 1.05) of Angus and Nellore cannulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin during the finishing phase. (+): presence of MON; (-): absence of MON.	79
Figure 29: Effect of breed factor on OM digestibility (%) of Angus and Nellore cannulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin during the finishing phase (P= 0,05) (SEM = 0,68).	79
Figure 30: Interaction between breed factor and monensin factor on protozoa percentage <i>Dasytrichia</i> (A; SEM = 0.66) and <i>Entodinium</i> (B; SEM = 0.66) of Angus and Nellore cannulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin. ^{a,b} Mean with different letters differ significantly. A(-): Angus non supplemented with Mon; A(+): Angus supplemented with Mon; N(+): Nellore supplemented with Mon; N(-): Nellore non supplemented with Mon.	81
Figure 31. Shannon diversity index for breed factor (A), corn processing type factor (B) and MON factor (C). Chao's richness estimator for microbial communities in the rumen of Angus and Nellore cannulated (D), corn processing type factor (E) and MON factor (F).	82
Figure 32: Non-metric multidimensional scaling (NMDS) representation of the Bray–Curtis dissimilarity metric for ruminal content of cannulated Angus and Nellore bulls (A), corn processing type (B) and inclusion or not of MON (C).	83
Figure 33. Relative abundance of the top seven phyla of ruminal bacterial communities observed in Angus and Nellore bulls (A), fed with different corn processing type (B) and supplemented or not with MON (C).	84
Figure 34. Relative abundance between <i>Clostridiales</i> (A), <i>Butyrivibrio</i> (B), <i>Succinivibrionaceae</i> (C) and <i>Prevotella</i> (D) communities founded on rumen of Angus and Nellore cannulated bulls submitted to different nutritional strategies.	85
Figure 35. Relative abundance between <i>Butyrivibrio</i> (A), <i>Firmicutes</i> (B) e <i>Prevotella</i> (C) communities present on Angus and Nellore cannulated bulls supplemented with MON or not.	86
Figure 36: Effect of corn processing type on rumen papillae height (mm) (A; SEM = 0.86) and breed on rumen papillae KLT (B; SEM = 0.39) of Angus and Nellore cannulated bulls fed with finely ground corn or high-moisture corn with addition or not of monensin. MF: finely ground; MU: high moisture corn.	88

TABLE LIST

Table 2. Feeding behavior and particle selectivity of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin during the transition's phases.	38
Table 4. Dry matter intake, rumen pH, rumen temperature and oxi-redox potential of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin.	48
Table 5. Products from rumen fermentation of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 4 th experimental day.	52
Table 7: Products from rumen fermentation of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 12 th experimental day.	59
Table 8: Products from rumen fermentation of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 16 th experimental day.	62
Table 9: Products from rumen fermentation of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 20 th experimental day.	64
Table 10: Products from rumen fermentation of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 24 th experimental day.	66
Table 11: Products from rumen fermentation of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin on 28 th experimental day.	68
Tabela 12: Effective and potential rumen degradability of DM, Starch (ST), crude protei (CP), acid detergente fiber (ADF) and neutral detergente fiber (NDF) of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin.	71
Table 13: Nutrient's digestibility of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin during the finishing phase.	77
Table 14. Total and differential count of protozoa of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin.	80
Table 15. Rumen morfometrics of Angus and Nellore bulls fed with finely ground corn or high-moisture corn with addition or not of monensin during the finishing phase.	87

SUMMARY

Chapter 1

1. Literature review	16
1.1 Genetic groups.....	16
1.2 The ruminal environment and nutritional strategies	18
2. HYPOTHESIS AND OBJECTIVE.....	23
3. REFERENCES.....	24

Chapter 2

1. INTRODUCTION.....	30
2. MATERIAL AND METHODS	30
3. RESULTS.....	37
4. DISCUSSION	88
5. CONCLUSION	92
6. REFERENCES.....	92

CHAPTER 1

GENERAL CONSIDERATIONS

Beef cattle is indeed one of the most significant activities of the Brazilian economy. According to the Brazilian Association of the Beef Importation Industry (ABIEC - “*Associação Brasileira das Indústrias Importadoras de Carne*” 2021) in the year 2020, Brazil had a reduction in the gross domestic product (**GDP**) of R\$ 7.4 million, which represents a drop of 4.1% compared to the previous year. However, the decrease in GDP increased the agriculture representation on the overall GDP of the country. The GDP of the agriculture sector increased from 8.4% to 10.0%, proving its importance for the Brazilian economy. Moreover, Brazil is one of the biggest beef exporters, exporting beef products to 157 countries and during the period previously mentioned, the beef products exportation increased by 8%.

Due to the market pressure, regarding both quantity and quality in beef products, the profile of cattle finished in the Brazilian feedlot has been changed in the last few years. According to Silvestre e Millen (2020), in a survey conducted in 2019, Brazilian beef cattle nutritionists reported that 85.0% of the feedlots Nellore cattle (zebu) and 52.0% finishing crossbreed cattle (zebu).

Several Brazilian researchers reported that taurine cattle have a greater performance when finished on a feedlot, compared to zebu cattle (CUCKI, 2006; CRUZ et al., 1995; LEME et al., 2000; LANNA et al., 1998). It could be justified by works of literature reports that show that zebu cattle are more susceptible to metabolic diseases than taurine cattle (PACHECO ET AL., 2012; MILLEN ET AL., 2015) such as acidosis, diarrhea, bloat, liver abscess and laminitis. Thus, a deeper understanding of the ruminal environment, and the characterization of the microbiota of these different genetic groups, seems to be significant to better nutritional planning for both transition and finishing phases to high-energy diets.

1. LITERATURE REVIEW

1.1 Genetic groups

Jorge (2013), when studying the origin and evolution of zebu and taurine cattle, reported that these different genetic groups had their origin in independent places and that different forms of creation and feeding made these differ in terms of their metabolic and nutritional evolution.

Nellore animals, *Bos taurus indicus*, are originally from India and were introduced to Brazil in the early 19th century, feed, for the most part, on forages with reduced digestibility, higher proportions of stem, and low nutritional value during the dry period (Characteristic of the tropical

Furthermore, Nellore cattle also presented an increase of ruminal communities, *Clostridiales* (Gram positive), *Butyrivibrio* (Gram positive), and *Prevotella* (Gram negative) when compared to Angus, only *Succinivibrionaceae* (Gram negative) were higher in Angus animals, corroborating the higher DMI and consequently higher starch load to be fermented.

5. CONCLUSION

During the transition period ruminal fermentation pattern and bacteria community are different for Angus cattle. Angus breed appears to have a rumen more prepared for concentrated diets than the Nellore cattle, with a homogeneous bacteria community.

6. REFERENCES

Association of Official Analytical Chemists - AOAC. Official Methods of Analysis. 16. ed. AOAC, Washington, DC. 1995.

ANDRADE, B.G.N., BRESSANI, F.A., CUADRAT, R.R.C. The structure of microbial populations in Nelore GIT reveals inter-dependency of methanogens in feces and rumen. *J Animal Sci Biotechnol* 11, 6 2020.

CARVALHO, S.; RODRIGO, M. T.; BRANCO, R. H. et al. Comportamento ingestivo de cabras 5 Alpinas em lactação alimentadas com dietas contendo diferentes níveis de fibra em detergente neutro proveniente da forragem. **Revista Brasileira Zootecnia**. 35:562-568. 2006.

DEHORITY, B. A. **Classification and morphology of rumen protozoa**. Wooster: Ohio Agriculture Research and Development Center, 1977.

DILL-MCFARLAND, K. A.; BREAKER, J. D.; SUEN, G.. Microbial succession in the 10 gastrointestinal tract of dairy cows from 2 weeks to first lactation. **Scientific Reports**. 7:40864. 2017.

ERWIN, E.S.; MARCO, G.J.; EMERY, E.M. Volatile fatty acid analyses of blood and rumen fluid by gas chromatography. **Journal of Dairy Science**, v.44, n.9, p.1768-1771. 1961.

FOLDAGER, J. **Protein requirement and non-protein nitrogen for high producing cow in early lactation**. Tese (Doutorado em Ciência Animal) – Michigan State University, East Lansing, MI. 1977.

GALYEAN, M. L., D. G. WAGNER, and F. N. OWENS. 1979. Corn particle size and site and extent of digestion by steers. *Journal of Animal Science*. 49:204. 1979

GOMES, R. C. et al. Leveduras vivas e monensina em dietas de alto concentrado para bovinos: parâmetros ruminais e degradabilidade" in situ". *Revista Brasileira de Saúde e Produção Animal*, v. 11, n. 1, 2010.

HARB, M. Y., V. S. Reynolds, and R. C. Campling.. Eating behavior, social dominance and voluntary intake of silage in groupfed milking cattle. *Grass Forage Sci*. 40:113–118. 1985.

HEINRICHS, J.; KONONOFF, P. In evaluating particle size of forages and TMRs using the Penn State Particle Size Separator. **Dairy Animal Science**. 1-14. 1996.

HENDERSON G, COX F, GANESH S, JONKER A, YOUNG W, ABECIA L. Rumen microbial community composition varies with diet and host, but a core microbiome is found across a wide geographical range. *Sci Rep*. 2015; 5:14567

JORGE, W. A genômica bovina - origem e evolução de taurinos e zebuínos. **Veterinária e Zootecnia**, v. 20, n.2, p. 217-237, 2013.

KULASEK, G. A. A micromethod for determination of urea in plasma, whole blood cells using urease and phenol reagent. **Pol. Arch. Weter**. 15:801-810. 1972.

LITHERLAND, N.B. **Adequacy of processing adjustment factors (PAF's) and intake discounts for dairy cows**. Invited Presentation. Oklahoma Cattle Grain Processing Symposium. p. 110-116. 26, 2006

MEHRES, A. Z.; ØRSKOV, E. R. A study of the artificial fiber bag technique for determining the digestibility of feeds in the rumen. **Journal Agricultural Science**. 88:645-28 650. 1977.

NOCEK, J. E. 1987. Characterization of in situ dry matter and nitrogen of various corn grain forms. *J. Dairy Sci*. 70:2291.

NOCEK, J. E., and S. TAMMINGA. Site of digestion of starch in the gastrointestinal tract of dairy cows and its effect on milk yield and composition. *J. Dairy Sci*. 74:3598. 1991

PERES ASSUMPÇÃO, A.H. The individual and associated use of monensin, tannins and calcium nitrate in the feeding of cattle promote a reduction in the emission of methane gas. Dissertação (Mestrado em Zootecnia) - Faculdade de Zootecnia e Engenharia de Alimentos, Universidade de São Paulo, Brasil, 2021.

PEZZATO, L.E. et al. Avaliação de dois métodos de determinação do coeficiente de digestibility aparente com a tilápia do Nilo (*Oreochromis niloticus*). *Acta Scientiarum*, Maringá, v. 24, n. 4, p.965-971. 2002.

PITTMAN, K. A and BRYANT, M. P. Peptides and other nitrogen sources for growth of *Bacteroides ruminicola*. f. *Bacteriol.*, 88. 401-10. 1964.

POORE, M. H.; MOORE, J. A.; ECK, T. P. et al.. Effect of fiber source and ruminal starch degradability on site and extent of digestion in dairy cows. **Journal of Dairy Science**, 76:2244-2253. 1993. 14

ROBLES, V.; GONZÁLEZ, L. A.; FERRET, A. et al. 2007. Effects of feeding frequency on intake, ruminal fermentation, and feeding behavior in heifers fed high-concentrate diets. **Journal of Animal Science**, 85:2538-2547.

RUSSELL, J. B. Fermentation of peptides by *Bacteroides ruminicola* B\4. *Appl. Environ. Microbiol.*, 45,1566-74. 1983

SAS. **SAS User's Guide: Statistics** (Version 5 Ed.). SAS Inst. Inc., Cary, NC, 2003.

VAN SOEST, P. J.; ROBERTSON, J. B.; LEWIS, B. A. Symposium: carbohydrate methodology, metabolism, and nutritional implications in dairy cattle. **Journal of Dairy Science**, 74(10):3. 1991.

WALLACE, R. J .. MCKAIN, N. and BRODERICK, G. A. Breakdown of different peptides by *Prevotella* (*Bacteroides*) *ruminicola* and mixed microorganisms from the sheep rumen. (1993). *Curro Microbiol.*, 26, 333-6.