University of São Paulo
“Luiz de Queiroz” College of Agriculture

Mechanical processing during harvesting of snaplage on performance of beef cattle in feedlot

Daniel Furtado Dardengo Sant’Anna

Dissertation presented to obtain the degree of master’s in science. Area: Animal Science and Pastures

Piracicaba
2022

Daniel Furtado Dardengo Sant'Anna
Animal Scientist

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versão revisada de acordo com a Resolução CoPGr 6018 de 2011

Advisor:
Prof. Dr. **LUIZ GUSTAVO NUSSIO**

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Sant’Anna, Daniel Furtado Dardengo

Mechanical processing during harvesting of snaplage on performance of beef cattle in feedlot / Daniel Furtado Dardengo Sant’Anna. - - versão revisada de acordo com a Resolução CoPGr 6018 de 2011. - - Piracicaba, 2022.

56 p.

Dissertação (Mestrado) - - USP / Escola Superior de Agricultura “Luiz de Queiroz”.

1. Snaplage 2. Silagem de milho planta inteira 3. Substituição de volumoso 4. Tamanho de partículas 5. Desempenho animal I. Título

To my mother and grandmother Maria da Penha and Maria de Lourdes and my whole family.
I DEDICATE

ACKNOWLEDGMENTS

This study was financed in part by the Conselho Nacional de Desenvolvimento Científico e Tecnológico - Brasil (CNPq).

A special thanks to:

My advisor Prof. Dr. Luiz Gustavo Nussio.

My co-advisor Drª Greiciele de Morais and Prof. Dr. Rafael Reis.

All my friends and colleagues from the Forage Quality and Conservation Team.

Prof. Dr. Arlindo Saran Netto from FZEA-USP for your hospitality on the Fernando Costa Campus during my stay in Pirassununga, São Paulo.

Prof. Dr. Paulo Henrique Mazza Rodrigues from FMVZ-USP for your generosity with all members of QCF team during the time we stayed in the Fernando Costa Campus in Pirassununga, SP.

Dr. Flavio Perna Júnior, Gilmar Botteon, Ricardo Galleni, Dione Silva, André Zanquetin, Manoel Santos and Mr. Cruz for all support in the experiments.

All the professors and employees of the Animal Science Department – ESALQ -USP and FZEA-USP.

Carlos Cesar, Daniel, and Joyce from EsalqLab.

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RESUMO

Processamento mecânico durante a colheita da snaplage no desempenho de bovinos de corte confinados

A *snaplage* é uma fonte rica em energia devido à alta participação potencial de grãos. Esse ingrediente tem substituído dietas de alto grão nos confinamentos de bovinos de corte no Brasil, pois, além da contribuição energética possui uma boa fração fibrosa, proveniente da palha, do sabugo e do pedúnculo da espiga. Um fator decisivo na ensilagem da *snaplage* é processamento mecânico, o tamanho de partículas deve conjugar interesses como garantir a efetividade de compactação da massa de forragem durante a ensilagem, estimular a ruminação e promover elevada digestibilidade ruminal da matéria seca ingerida. Existem evidências de que alterações agronômicas na cultura podem modificar a proporção de grãos na espiga e a respectiva eficácia de picagem dos dispositivos mecânicos no processamento da colheita da *snaplage*. Neste contexto, objetiva-se com o presente trabalho: em uma cultura de milho de primeira safra, impor tamanhos teóricos de picagem de partículas na colheita de *snaplage* e verificar como resultam em desempenho de bovinos de corte confinados; identificar a viabilidade de utilizar a *snaplage* como fonte única de volumoso na dieta de bovinos de corte confinados. Foram utilizados 65 animais nelores em baias individuais em delineamento experimental de blocos ao acaso. Para os animais que receberam os tratamentos com *snaplage* as dietas continham 30% volumoso e 70% de concentrado com base na matéria seca, já para os animais que receberam o tratamento com SMPI a dieta continha 25% de volumoso e 75% de concentrado com base na matéria seca. Para a avaliação de desempenho animal foram utilizados como indicadores zootécnicos CMS, GMD, eficiência alimentar, PCQ, RC, AOL, EGS e EGP, também foram realizadas avaliações de comportamento ingestivo e índice de seleção. Ademais, foram realizadas medidas nos silos experimentais no intuito de caracterizar a silagem utilizada durante a avaliação de desempenho animal, portanto, foram realizadas medidas de densidade, estabilidade aeróbia, contagem de microrganismos e de tamanho médio de partículas durante o período de avaliação de desempenho animal. Após a avaliação de desempenho animal, silagem, dietas e sobras foram analisadas, a fim de mensurar suas características químicas (MS, MM, PB e FDN). No presente estudo, os animais alimentados com silagem de milho planta inteira quando comparados com os alimentados com as dietas contendo *snaplage*, apresentaram maior consumo de matéria seca, no entanto, isto não resultou em alterações sobre o ganho médio diário, peso corporal final, eficiência alimentar. Contudo, os animais que receberam dietas contendo *snaplage* colhida com tamanho teórico de corte 9 mm apresentaram menor tempo de ruminação e peso de carcaça. Quanto ao índice de seleção, os animais que receberam a dieta silagem de milho de planta inteira (SMPI) colhida com 15 mm apresentaram recusa à peneira de 8 mm, provavelmente por já terem suprido a demanda de fibra. Os tamanhos teóricos de partículas foram diferentes dos observados, logo, foram encontrados tamanhos médios de partículas (TMP) entre 6.6 e 7.4 mm para *snaplage* e para SMPI foi encontrado um TMP de 9.9 mm. Portanto, não houve diferença no desempenho dos animais alimentados com *snaplage* colhida sob tamanhos de partícula variando entre 6.6 e 7.4 mm e essa pequena variação não propiciou diferença no desempenho animal e, sobretudo, que esse ingrediente se comportou satisfatoriamente quando incluído na proporção de 30% e como única fonte de volumoso em dieta de bovinos de corte confinados.

Palavras-chave: Desempenho animal, Silagem de milho planta inteira, *Snaplage*, Substituição de volumoso, Tamanho de partículas

ABSTRACT

Mechanical processing during harvesting of snaplage on performance of beef cattle in feedlot

Snaplage is a rich source of energy due to the high potential share of grains. This ingredient has high-grain substitutes in the confinement of beef cattle in Brazil, in addition to the energy contribution, as the diet comes from the stalk and the husk of the ear. One in silage is mechanical, the mass size of conjugation of materials as processing for silage compaction, promoting a reduction and enhancing the digestion. Therefore, agronomic modification devices that can modify the crop and the proportion of grains on the ear and the respective chopping operation of the mechanical devices in snaplage crop processing. The objective of the present work is the first crop, to impose theoretical particle sizes in the snaplage crop and verify how they result in the performance of confined beef cattle; to identify the feasibility of using snaplage as a single source of roughage in the diet of beef cattle in a feedlot. Sixty-five Nellore animals were used in individual pens in a randomized complete block design. For the animals that received the snaplage treatments diets contained 30% by roughage and 70% of concentrate based on dry matter, for the animals that received the treatment with WPCS the diet contained 25% by roughage and 75% of concentrate based on dry matter. For the evaluation of animal performance, DMI, ADG, feed efficiency, HCW, dressing, LM area, and 12-th rib-fat and they used as indicators, as well as estimates of ingestive behavior and selection. In addition, density measurements, aerobic evaluation, microorganism measurement, and mean particle size were performed during the animal performance evaluation period, and the evaluation of animal performance, silage, diets, and orts were analyzed to measure chemical characteristics (DM, MM, after CP and NDF). In the present study, animals fed with whole plant corn silage, when compared to those fed a diet containing snaplage, showed higher dry matter intake, however, it did not result in changes in average daily gain, final body weight, and food efficiency. However, animals that received a diet containing snaplage harvested with a theoretical cut size of 9 mm had lower rumination time and carcass weight. As for the sorting index, the animals received a diet of whole plant corn silage (WPCS) harvested with 15 mm of refusal to the 8 mm sieve, probably because they had already supplied the fiber requirement. The theoretical sizes of SM particles found were different from those observed, therefore, were mean particle sizes (MPL) 6.6 were and 7.4 mm for snaplage and TMP found to 9.9 mm. Therefore, there was no difference in the performance of the animals fed with snaplage under sizes of partial variation of 6.6 and 7.4 mm and this small difference did not provide the difference between animal performance and, above all, that this ingredient behaved satisfactorily included in the proportion of 30 % harvested and as the only source of roughage in the diet of confined beef cattle.

Keywords: Animal performance, Roughage replacement, Snaplage, TLOC, Whole plant corn silage

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LIST OF ABBREVIATIONS

ADG: average daily gain
CP: crude protein
DM: dry matter
DM corr: dry matter corrected for silage volatile compounds
DMI: dry matter intake
HCW: hot carcass weight
iNDF: neutral detergent fiber intake
MPL: mean particle length
NDF: neutral detergent fiber
NEg: net energy for gain
NEm: net energy for maintenance
pef: physically effective factor
PSPS: Penn State particle separator
rNDF: roughage neutral detergent fiber
riNDF: roughage neutral detergent intake
SNAP: snaplage
TLOC: theoretical length of cut
TMR: total mixed ration
WPCS: whole plant corn silage
WSC: water soluble carbohydrates

INTRODUCTION

Snaplage is an energy-rich food due to the high potential participation of grains. This ingredient has a great opportunity to replace high-grain diets in beef cattle feedlots, because, in addition to the energy contribution of starch, it has a considerable fibrous fraction, coming from husks, cob, and shank. In addition, for the mechanical processing of snaplage, it is necessary to use self-propelled forage harvesters joined through a specific device with a platform for corn snap head (Salvo et al., 2020). The chopping must combine interests as a stimulus to rumination, and high ruminal digestibility, in addition, to assure an easy-to-compact forage mass, in terms of silage management.

The use of pull-type harvesters is very common in Brazil, due to the high cost of self-propelled harvesters (Bernardes and Rêgo, 2014). The self-propelled harvesters have a system called “corn-cracker” that is constituted of rollers that crush the grains as the mass to be ensiled passes through. This system aims to break the grain pericarp of making starch available for greater use of this carbohydrate by increasing the surface area of contact (Shinners, 2000), allowing microorganisms to adhere to the substrate.

In this sense, forage processing during harvest is a valuable management measure, as it ensures the physical quality of the material, maintaining the particle size of the vegetative fraction, with maximum processing of the plant's grain fraction. A well-managed harvesting, especially if performed by self-propelled machines with crushing rollers (“crackers”), reduces the particle size of corn grains and increases starch digestibility in the total digestive tract (Bal et al., 2000; Cooke and Bernard, 2005). This processing forms fissures breaks the granules and eliminates the pericarp, which constitutes a physical barrier to microbial attack and the action of the animal's digestive enzymes. However, processing efficiency can be affected by several factors, such as dry matter content, grain texture (Shinners, 2003; Ferraretto et al., 2018), and the proportion of ear components. In addition, more intense mechanical processing allows for greater density of the ensiled mass, as it facilitates the compaction and exhaustion of oxygen, factors that are known to be important in reducing losses resulting from ensiling.

The objective of the present work is a first crop of corn to impose theoretical particle sizes in the *snaplage* crop and verify how they result in the performance of confined beef cattle; to identify the feasibility of using snaplage as a single source of roughage in the diet of beef cattle in a feedlot. The hypothesis the of present work is an increment of theoretical particle sizes in *snaplage* crops would result in decreseament in the animal performance of beef cattle in the feedlots.

1. REVIEW OF LITERATURE

The need to overcome seasonality in the production of good quality forage and to meet the growing demand for animal protein, both domestic and export, boosted Brazil in the development of feed conservation techniques. One of the most used strategies is silage, which consists of preserving food by acidification, resulting from the fermentation of soluble plant sugars.

Traditionally, corn is the most used plant for silage, as it meets all the requirements for making good silage, such as quality chemical composition, rich in fermentable substrates and other nutrients; low buffering power, and ideal dry matter content to achieve a desirable fermentation. Another good point to highlight is the machines used in order to harvest the crop, in Brazil pull-type harvesters are very common and the main issue is because of the high cost of self-propelled harvesters (Bernardes and Rêgo, 2014). Moreover, this traditional way of harvesting may result in silages with low particle size uniformity and a high content of long particles (Bernardes and Rêgo, 2014; Bernardes et al., 2012a). The biggest problem is the pattern of particles, unevenness in the cutting may enhance the deterioration, once affecting the compaction and providing more porous silage which increases air penetration and may compromise the nutrition value of the silage as well (Muck et al., 2003). Harvesters pulled by a tractor had more particles retained on the top sieve (>19 mm) and less on the middle sieve (8-19 mm). This cutting pattern may increase silage porosity and enhance deterioration (Muck et al., 2003).

Packing density is a sine qua non-condition for good silage, once high porosity results in a larger reservoir of oxygen (Borreani et al., 2018). The oxygen allows aerobic microorganisms to consume readily available carbohydrates. So, DM losses are correlated with high porosity of silage, thus according to Köhler et al. (2013), DM losses were inversely and significantly related to density. But, for drier silages, the packing density is more difficult than WPC, because the porosity is higher and mass with high DM content makes it difficult to pack the mass.

Sealing is another important factor in the quality of silage because sealing has the function of avoiding air penetration and consequently avoiding silage deterioration. The most used material is plastic films in warm climates can readily become more permeable to air (Daniel et al., 2019). Nowadays with the advancement of technology film has three functions, for instance, the film should prevent damage caused by rain and birds, secondly, the film should be UV resistant in order to maintain the material intact after prolonged exposure to sunlight. Finally, the last function is kept in anaerobic conditions during ensiling and storage

(Bernardes, 2016; Daniel et al., 2019).

On top of that, a good mass fermentation results in the preservation of the forage crop as silage. Points to highlight are pH and quantifying the amount of the production of organic acids in order to evaluate the quality of silage fermentation. In the ensiling process lactic acid is produced by lactic acid bacteria and this organic acid is usually found in the highest concentration in silages and contributes to the most decline in pH during fermentation because is stronger than other organic acids presented in the silages (Kung et al., 2018). Typical concentrations of lactic acid in WPCS range from 2 to 4% of the DM, on the other hand for drier silages, likewise *snaplage* this value decreases to a concentration of around 1 to 2% of the DM (Kung et al. 2018; Gusmão et al., 2021). Another important organic acid for forage conservation is acetic acid which has a very important function, for instance, prevents the proliferation of yeasts and fungi and enhances the aerobic stability of the silage.

Microbial populations are correlated with good quality silage, because high contents of aerobic microorganisms will impair the quality of silage, for instance, a great number of yeasts and molds will enhance the spoilage of the mass ensiled, furthermore impair the performance of animals who might intake this low-quality silage (Santos et al., 2015). The high number of molds, likewise numbers > 6 $\log_{10}$ cfu/g are highly correlated with aerobically spoiled silages. So, aerobic deterioration occurs mostly during in the feed-out phase, because in this phase it’s impossible to protect the silo against oxygen penetration once the silo is opened. Several studies are developed in order to solve the problem of the feed-out rate. According to Bernardes et al. (2021) is a rate above 250 kg of silage/m², because this daily removal rate did not show significant differences between the core and peripheral areas for pH, lactic acid, or molds, in addition, this feed-out rate presented 92.5% of the silage without aerobic deterioration.

In the beef industry, WPCS is the primary source of roughage in finishing diets, which was used by 69.4%, followed by sugarcane bagasse (11.1%) (Silvestre and Millen, 2021). In addition, *snaplage* has generated great interest in feedlots in Brazil. The main reasons for the popularity of *snaplage* are the logistic benefits because *snaplage* is a combination of energy and fiber, energy provided by grain and fiber provided by cob and husks, being capable of stimulating chewing activity (Daniel et al., 2019).

To sum up, the feedlots diets have changed a lot over the years according to Silvestre and Millen (2021) the average inclusion level of grain increasing in the last decade based on the percentage of nutritionists who include more than 66% of grains in finishing diets. Another great change is the level of roughage inclusion in finishing diets, nowadays is recommended 16.8% of diet DM, this number represented approximately a 42% decrease compared with the first survey conducted in 2009 (Millen et al., 2009), this number decreased a lot in order to turn simpler the logistic in a feedlot daily management. In addition, another good point with the increasement of large feedlot operations is still expanding in Brazil and fresh feeds, such as chopped sugarcane and sugarcane bagasse, were gradually replaced by conserved feeds. Moreover, corn silage has a great contribution to the energy of finishing diets (Silvestre and Millen, 2021).

In addition to whole plant silage, several techniques for corn conservation have been recently developed. One of these various techniques is “snaplage” or silage from the whole ear, which is composed of husks, cob, grain, and shank. This technique has been gaining prominence, especially in beef cattle feedlots, as an energy source, due to its high starch content and economic character that attracts nutritionists, as it is a combination of fiber and grains (Mahanna, 2008). On top of that, *snaplage,* in terms of morphological composition, diverges from earlage (grain and cob), in addition, typical earlage requires at least two separate operations (harvesting and grinding), on the other hand, *snaplage* allows harvesting and processing the whole ear in a unique operation and this brings a large logistic advantage. *Snaplage* has significant amounts of NDF (20 – 25%, DM basis) and starch (50 – 60%, DM basis), therefore *snaplage* is a good feedstuff, especially in beef cattle finishing diets. In addition, harvesting *snaplage* permits an increase in stocking rate by ~ 10%, because it's necessary to use separate areas to produce corn grain and WPCS (Daniel et al., 2019). *Snaplage* is harvested with low moisture (45 – 35% of moisture) and this factor may lead to low-quality silage and include the conservation process because the restricted fermentation will decrease the load of fermentation products. It’s necessary the processing the grain in the *snaplage* in order to break down the protein matrix which surrounds the starch granules and releases the starch to digestion easier in the rumen.

The corn kernel is formed by germ, endosperm, and pericarp. The endosperm consists of a translucent area, which is referred to as vitreous or corneal, and an opaque amorphous area, which is referred to as soft or mealy. The proportion of these two areas varies with the cultivar and determines the grain texture. The vitreousness or texture of the corn grain is associated with the physical structure of the endosperm and the degradation of starch in the rumen. The endosperm is made up of approximately 86% starch and 10% protein and small amounts of minerals and lipids (Fornasieri Filho, 1992). The texture is a characteristic that defines the degree of vitreosity (hardness) of the grain, which is determined by the proportion between vitreous and floury endosperm in relation to the total endosperm. Grain vitreousness is used as a grading factor to determine grain texture, and grains can be classified as hard, semi-hard, and soft. The starch granules of the endosperm are surrounded by a protein matrix (Duvick, 1961). Starch granules of hard corn are structurally surrounded by numerous protein bodies incorporated into the endosperm's cellular matrix. This makes the granules of starch “packaged”, making it difficult for the enzymes of the rumen microorganisms to work. In corn with farinaceous endosperm, the protein matrix loosely surrounds the starch granules, therefore, the action of the enzymes of the ruminal microorganisms is facilitated and, consequently, there is greater degradability of starch.

However, there is a scarcity of data on the use of *snaplage* in Brazil, especially regarding the theoretical length of cut to produce this silage, and the specific effects of the fibrous content present mainly in the cob, husks, and shank fractions. On the other hand, corn hybrids can differ in proportions of the vitreous and floury endosperm. In Brazil, most commercial hybrids have vitreous endosperm (Daniel et al., 2019; Gusmão et al., 2021). Companies have developed an increase in genetically corn hybrids based on grain yield and other factors, likewise disease resistance (Bendia et al., 2021). Several studies demonstrate variations in starch digestibility for different corn hybrids, which can influence in order to different animal performance responses, moreover, an increment in grain production does not influence a good corn silage quality, once grain digestibility varies considerably among corn hybrids and their proportions of floury and vitreous endosperm content (Crevali et al., 2017, 2018, 2019; Bendia et al., 2021).

The theoretical length of cut (TLOC) is another important factor to be analyzed in the silage process. Ferraretto and Shaver, (2012) performed a meta-analysis consisting of 106 treatments of 24 articles published in several journals between 2000 and 2011. Different dry matter contents were evaluated at harvest, grain processing (opening of the crushing rolls), and theoretical length of cut for whole plant corn silages. The theoretical length of cuts evaluated was 4.8 to 6.4 mm; 9.3 to 11.1 mm; 12.7 to 15.9 mm; 19 to 19.5 mm; 25.4 to 28.6 mm and greater than 32 mm. However, the different length of cut did not affect the performance of animals for dairy cows, instead for beef cattle the literature does not have clear information about this difference. The presence of long fiber in the diet is positively associated with masticatory activity and buffering of ruminal pH (Mertens, 1997). Different particle sizes influence the rate of passage of food through the rumen. The larger the particle size, the longer the retention time of this material in the rumen-reticulum, directly influencing its degradation, as it allows greater adherence of microorganisms to the particles, therefore, greater degradation of the material. Understanding the flow of digesta is important to predict food utilization strategies in animal nutrition.

According to Allen (1997), with the reduction in the size of feed particles, there is an increase in the consumption of dry matter, triggering, however, a decrease in digestibility and in the retention time of the solid fraction in the rumen. This affects the efficiency of colonization and food degradation by ruminal microorganisms, as the amount of surface area required specifies the availability and accessibility of microorganisms to degradation sites (Russell, 2002). For ruminant animals, the long fiber in the diet is very important, as it is a component that stimulates rumination, the secretion of saliva and, in this way, helps to maintain ruminal homeostasis. Adequate levels of physically effective neutral detergent fiber (peNDF) in ruminant diets are essential for rumen health, as rumen buffering occurs through saliva. Ruminant saliva is rich in buffer solutions such as bicarbonate and phosphate, thus preventing cases of ruminal acidosis and providing greater stability of the physiological and metabolic processes of the rumen (Silva and Neumann, 2012).

To summarize, it's necessary to pay attention to the quality of roughage sources in beef cattle finishing diets, because these different roughage sources have different physical and chemical characteristics. In the finishing diets nutritionists concerning with roughage NDF, because this influences in DMI of the animals. According to Caetano et al. (2015) is recommended 12.8% of rNDF is in beef cattle finishing diets because this content of rNDF optimizes the performance of the bulls in the feedlot. So, it's necessary more studies in order to find good roughage sources to replace the traditional roughage source in feedlots WPCS, according to Goulart et al. (2020) WPCS used with caution when these diets have only 10% rNDF (DM basis), because this amount of may not prevent ruminal disorders.

At least, *snaplage* has great potential in order to replace traditional beef cattle finishing diets roughage sources, likewise WPCS, sugarcane bagasse, because this feedstuff is a combination of fiber and energy (grain + cob and husks), in addition, the use of *snaplage* in feedlots may help the logistic in the feedlot management, moreover, *snaplage* growers seek maximum return on investment, because *snaplage* may provide a longer harvest window, on the other hand, the leftovers from the crop can be used for others animals categories with less demanding through the technique of *stalklage* which is used only culm of a corn plant or soil protection, optimizing the whole process in the farm.

3. MATERIALS AND METHODS

The animal performance trial was carried out at the University of São Paulo in Pirassununga, SP at Fernando Costa Campus (FZEA)) and the feed samples were sent to the Luiz de Queiroz College of Agriculture – University of São Paulo, to be analyzed. All the animal procedures were by the guidelines of the Animal Care and Use Committee of the Faculdade de Zootecnia e Engenharia de Alimentos (FZEA-USP) (protocol number 9696190521).

3.1. Ensiling

The corn culture was raised on the Fernando Costa Campus of the University of São Paulo in Pirassununga (FZEA), as a first crop in the 2019/2020 harvest season. Agronomic traits were carried out according to the recommendations of fertilization and liming of the corn crop for São Paulo (Boletim 100 – IAC/FUNDAG, 1997). The hybrid used was the AG 8690 PRO 3 (semi-dent), and ears (corn kernels, cob, husks, and shank) were harvested to reach 60% MS, approximately 120 days after seeding, using a self-propelled harvester (New Holland model FR 9060), coupled to a harvester platform (snap header) with size adjustment theoretical length of cut of 6, 9, 12, 15 mm. From the same field, to reach 35% DM, the hybrid used was the BM 709 (semi-dent) approximately 100 days after seeding, the whole plant (WPCS) was harvested as control silage adjusted to a theoretical length of 15 mm and equipped with a kernel processor with a distance between rolls of 1 mm. The WPCS was decided to use because of the low quality of *snaplage* and did not have the same hybrid to use in the study and was decided to use the BM 709 as WPCS.

The *snaplage* and WPCS were prepared and stored in surface-type silos, where they remained for seven months until the experiments with animals were carried out. All the silos were covered with white on black-sided polyethylene plastic sheets, and treatments achieved the dimensions of the following silo: SNAP 6 was 5.5 m width, 23 m length, and 1.6 m height, SNAP 9 was 6 m width, 22.10 m, length, and 1.4 m height, SNAP 12 was 5 m width, 20.70 m length, and 1.4 m height and SNAP 15 was 5 m width, 20 m length, and 1.36 m height. One tractor Massey Ferguson model 7415 was used to pack the chopped *snaplage* and aimed to reach a packing density of 600 kg/m^3. Silages' chemical compositions are described in table 1 and physical compositions are described in table 2. Therefore, the expected and observed mean particle sizes were different and the name of the treatment is to illustrate the mean particle sizes observed, for example, SNAP6 is about 6.6 mm of *snaplage*.

Table 1. Chemical and physical composition of silages (dry matter basis)

Nutrient (DM basis)	SNAP6	SNAP9	SNAP12	SNAP15	WPCS15
DM, %	63.9	65.2	62.4	62.1	36.3
NDF, %	33.9	30.6	37.9	32.1	52.4
CP, %	9.7	9.7	9.7	9.7	7.8
Ash, %	3.2	4.1	3.4	2.7	4.7

Table 2. Physical composition of silages

Nutrient (DM basis)	SNAP6	SNAP9	SNAP12	SNAP15	WPCS15	SEM
19 mm, %FM retained	7.4	8	9.9	10.6	4.9	2
8 mm, %FM retained	29.9	31.3	35.9	35	73.4	8.8
4 mm, %FM retained	43.2	42.9	38.4	37.5	12.1	3.2
Bottom pan, %FM retained	19.6	17.8	15.8	16.8	9.7	2.7
Expected MPL, mm	6	9	12	15	15	3.9
Observed MPL, mm	6.6	6.9	7.4	7.1	9.9	2.1
pef > 8 mm[1], %	37.3	39.3	45.8	45.6	78.3	16.7
pef > 4 mm[1], %	82.3	81.6	80.9	82.3	90.7	4
Grain processing						

Grains <4.75mm, %	81.1	82.2	82.2	81.1	75.1	2.9

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[1] pef: physically effective factor

3.1.1. Animals and housing

For the animal performance trial, 65 Nellore bulls were allocated to individual stalls, and divided into 13 blocks, according to the initial bodyweight The treatments were randomly distributed in each block. Treatments consist of a theoretical length of cut from snaplage sources obtained: 6 mm, 9 mm, 12 mm, or 15 mm, and whole plant corn silage harvested to reach 15 mm.

The diets were formulated to match typical commercial beef feedlot diets, to allow the animals to reach an average daily gain of 1.5 kg. Diets were also formulated to reach the same amount of NDF from forage (12.58%) and be iso-protein (13%) (Nasem, 2016). One hypothesis was based on the idea in the fibrous fraction contained in the snaplages must provide the only source of fiber in the diet, without the inclusion of other roughage ingredients. The animals were weighed individually, using a hydraulic squeeze chute equipped with a scale (Coimma, Dracena, SP, Brazil) at the arrival to determine the shrunk body weight (mean ± SD was 402 ± 37 kg). From the 75 animals in the group, 65 more homogenous ones were selected, and the outliers were removed from the trial.

Furthermore, upon their arrival, the bulls were dewormed and vaccinated against botulism, foot-and-mouth, and carbuncle diseases. Each pen had 9 m², covered on the roof and provided with a concrete floor. During the trial, the animals had free access to the water trough.

3.2. Diets

3.2.1.1. Adaptation diets

Firstly, all the bulls were adapted to the feedlot for 6 days with a receiving diet, and then to step-up adaptation diets for 21 days, before starting the trial. During the adaptation, the diets were changed to decrease the forage: concentrate ratio (Table 2.) In the first week of the adaptation period, the animals received Diet 1, in the second week, Diet 2, and in the last week, they were fed Diet 3.

Table 3. Composition of diets during the first 21 days of adaptation (dry matter basis)

Ingredient, %	Diet 1 (d1-7)	Diet 2 (d8-14)	Diet 3 (d15-21)
Whole-plant corn silage	70	50	30
Ground corn	23.75	43.75	63.75
Soybean meal	3	3	3
Urea	1.3	1.3	1.3
Limestone	1	1	1
Sodium chloride	0.2	0.2	0.2
Mineral supplement[2]	0.75	0.75	0.75

[2] mineral composition (DM basis): 200 g/kg Ca, 160 g/kg P, 60 g/kg S, 160 mg/kg Co, 2700 mg/kg Cu, 135 mg/kg I, 2,700 mg/kg Mn, 80 mg/kg Se, 8,100 mg/kg Zn, 1,600 mg/kg F, 4,000 mg/kg Monensin. Manufactured by Minerthal, Araçatuba, Brazil.

3.2.1.2. Experimental diets

After 21 days of adaptation, the bulls had their water and feed intake restricted for 16 hours, in order to measure the shrunk body weight. The average shrunk body weight of the animals at the beginning of the experimental phase was 399 ± 34 kg. After that, they were randomly allocated to thirteen blocks, according to their body weight (heaviest to lightest). Five pens composed each block. The animals are individualized. The experimental diets were: 1) SNAP 6 (Snaplage 6 mm + concentrate); 2) SNAP 9 (Snaplage 9 mm + concentrate); 3) SNAP 12 (Snaplage 12 mm + concentrate); 4) SNAP 15 (Snaplage 15 mm + concentrate) and 5) WPCS 15 (Whole plant corn silage 15 mm + concentrate). The concentrate of the diet was composed of ground corn, soybean meal, urea, and mineral supplement containing monensin (Table 2). The pens within each block were assigned randomly to one of the five treatments. The diets were formulated to attend to the bulls' requirements to reach 1.5 kg of weight gain per day (NASEM, 2016). Also, diets were formulated to reach iso-NDF and iso-protein. The experimental diets are shown in table 3.

Table 4. Experimental diets chemical composition (dry matter basis)

Ingredient, %	SNAP6	SNAP9	SNAP12	SNAP15	WPCS15
Whole-plant Corn Silage	-	-	-	-	25
Snaplage	30	30	30	30	-
Dry grounded corn	63.75	63.75	63.75	63.75	68.75
Soybean Meal	3	3	3	3	3
Urea	1.3	1.3	1.3	1.3	1.3
Limestone	1	1	1	1	1
NaCl	0.2	0.2	0.2	0.2	0.2
Mineral supplement[2]	0.75	0.75	0.75	0.75	0.75
Nutrients, %					
Dry Matter, %FM	73.73	79.95	78.03	77.03	63.16
Ash	3.67	3.82	3.12	3.41	3.86
Crude Protein	13.68	13.66	13.97	14.14	13.55
NDF	20.11	16.24	19.52	20.75	19.77
rNDF[3]	10.17	9.17	11.36	9.63	13.1

[2] mineral composition (DM basis): 200 g/kg Ca, 160 g/kg P, 60 g/kg S, 160 mg/kg Co, 2700 mg/kg Cu, 135 mg/kg I, 2,700 mg/kg Mn, 80 mg/kg Se, 8,100 mg/kg Zn, 1,600 mg/kg F, 4,000 mg/kg Monensin. Manufactured by Minerthal, Araçatuba, Brazil.

[3] rNDF: roughage neutral detergent fiber.

Table 5. Experimental diets physical composition

Item	SNAP6	SNAP9	SNAP12	SNAP15	WPCS15	SEM
19 mm, %FM retained	3.1	2.5	3.5	2.8	1.3	0.9
8 mm, %FM retained	7.3	9.7	11.5	7.5	22.9	2.9
4 mm, %FM retained	21.5	20.6	20.7	17.8	10.2	1.7
Bottom pan, %FM retained	68.2	67.2	64.3	72.0	65.6	4.1
MPL, mm	3.1	3.1	3.3	3.1	3.6	2.1
pef > 4 mm[1], %	31.8	32.8	35.7	28.0	34.4	2.9

[1] pef: physically effective factor.

3.2.2. Feeding and Animal Performance

The animals were fed once per day at 0800. Diets were delivered using a pull-type wagon (model Unimix 1200, Casale, São Paulo, Brazil). pre-weighing the concentrated ingredients and the silage for each diet and mixing for 15 minutes. The adjustment of the animal's DM intake was carried out according to the orts from the previous day and was weighted to correct the DM intake of the animals. Every day was weighted by the orts from the previous day, when the orts representing 5% or less of the total diet were provided for the animal we increased the offer by 1 kg of DM for the animal, on the other hand when the orts representing 10% or more of total diet were provided for the animal, we decreased the offer by 1 kg of DM for the animal. Every week, the samples of the silages and the concentrate were collected and dried at 55°C to correct the DM of the diets offered to the animals.

At the end of the experiment, the animals were weighed again to calculate the average daily gain (ADG) of the entire trial. The TDN, NEm, and NEg of the diets were calculated using mean values of observed shrunk BW, DMI, and ADG of the bulls individually (Zinn and Shen, 1998). Those same energy variables were estimated for the WPCS and SNAP silages. This estimation proceeded by subtracting the observed energy of the diets (as mentioned above) from the energy of the diets without the energetic contribution of the SNAP. For this, the TDN value of each ingredient was estimated using the equation of Weiss et al. (1992).

During the weighing and before slaughtering, the carcass quality of the animals was evaluated using ultrasound scanning technology (Cônsolo et al., 2021). The animals had their ribeye area and fat thickness measured, with the ultrasound probe placed in between the 12th and 13th ribs, above the *longissimus dorsi* muscle. Before each measurement, the animal was contained properly, and soy oil was applied at the skin surface to better conduct ultrasound waves. After that, the animals were transported to a commercial slaughterhouse (Frigol S.A., Lençóis Paulista, SP, Brazil). The hot carcass weights (HCW) were determined by summing up the two carcass halves.

3.2.3. Feeding behavior

The feeding behavior of the animals was evaluated based on visual observation of the oral activity of each animal every 10 minutes of the day. The oral activities were considered: ingestion, drinking, rumination, and idleness. Chewing time was defined as the sum of ingestion and rumination times. The chewing, ingestion, and rumination times per unit of DMI were calculated using the DMI measured on the day of determination of masticatory activity. Therefore, the number of daily meals and DMI per meal were calculated.

3.2.4. Chemical and physical analysis

During the overall trial, samples of silage, diets, and ingredients were collected and frozen, weekly. The collected samples were dried in a forced-air oven for 72 h at 55° C and ground to pass a 1 mm mesh screen (Willey mill, Arthur H. Thomas, Philadelphia, PA). The subsamples were analyzed for DM, ash, and ether extract (EE) according to the Association of Official Analytical Chemistry (AOAC) (1990; methods 934.01, 920.39, and 924.05, respectively). The nitrogen of the subsamples was analyzed according to the Dumas method 990.03 (AOAC, 2006), using a nitrogen analyzer (FP-2000A, Leco Corp., St. Joseph, MI, USA). After the measure of total nitrogen, crude protein was obtained by using a factor of

6.25 x N. The NDF was analyzed according to Mertens (2002), using amylase and sodium sulfite for the silages.

Snaplage, whole plant corn silage was weighed in subsamples with 25g each, and after that added 225g of deionized water and mixed for 1 min using a blender. The extract was filtered with 3 layers of cheesecloth and the pH was measured according to Santos et al. (2019) (DM 20 pH meter, Digimed Analítica, SP, Brazil). Then, it was centrifuged at 10,000 x g for 15 min at 4°C, and lactic acid (Pryce, 1969) and the concentrations of VFA were quantified. The concentrations of VFA, alcohols, and esters were analyzed using a gas chromatograph with a mass detector according to Santos et al. (2019) (GCMS QP 2010 plus, Shimadzu, Kyoto, Japan) using a capillary column (Stabilwax, Restek, Bellefonte, PA, USA; 60 m, 0.25 mm, i.d., 0.25 m). The DM content was corrected for the volatile compounds according to the equation proposed by Weissbach (2009).

Table 6. Fermentative profile of silages (DM corrected basis)

Item	SNAP 6	SNAP 9	SNAP 12	SNAP 15	WPCS 15
DM corr², % AF	60.2	61.7	59.2	58.6	35.5
pH	3.91	3.97	3.97	3.95	3.68
Lactic acid, %	2.63	2.06	1.35	1.91	2.24
Acetic acid , %	1.22	1.44	1.25	1.17	1.49
Ethanol, %	0.06	0.04	0.03	0.04	0.15
1,2-Propanediol, mg/kg	520	432	434	418	245
1-Propanol, mg/kg	1	1	4	2	128
2,3-Butanediol, mg/kg	119	322	385	382	371
Propionic acid, mg/kg	79	89	93	100	244
Ethyl lactate, mg/kg	41	26	24	29	88
Butyric acid, mg/kg	19	31	33	17	15
Ethyl acetate, mg/kg	2	1	1	2	7

To separate the grain fraction from the stover in SNAP and WPCS, a hydrodynamic separation method was applied (Savoie et al. 2004). The grains were weighed (250g), dried at 60ºC in an air-forced oven for 72h, and then analyzed for particle size distribution using a Ro-Tap Shaker (Bertel Ltda., Caieiras, SP, Brazil) equipped with 9 sieves with nominal square apertures of 9.50, 6.70, 4.75, 3.35, 2.36, 1.70, 1.18, and 0.59-mm, the bottom pan.

Sorting behavior was measured once per month according to the method of Leonardi and Armentano (2003). The roughage silages (SNAP and WPCS), as well as the diets and the orts, had the particle size distribution measured using 3 sieves (19, 8, 4 mm, and the bottom pan), of the Penn State Particle Size separator, according to the procedure described by Maulfair et al. (2011). The physically effective factor (pef>4) was obtained through the sum of the fraction retained on the sieves with the aperture 19, 8, and 4 mm.

3.2.5. In silo measurements

The density of the silages and the silo face removal layer, in addition to the measurements of height, width, and length of the silos were evaluated. These measurements were taken from the face of the silo panel, at the end of 30 days, although 3 times in the whole experiment. The height, width, and length measurements were taken with the aid of a tape measure. The silo face removal daily was measured using a tape measure and was calculated as follows: DS = amount of silage removed (m)/day. To determine the density, a drill coupled to a cylinder of known volume was used, being sampled 9 points from the top, middle, and bottom of the silo panel the cylinder has 5.08 cm of diameter, 30 cm of length, and a total volume is 607.7 cm^3. The samples were weighed to allow the estimation of silage density. The samples taken from the silo panel were saved as a composite sample for further analysis. The microbiological profile proceeded from a fresh sub-sample of silage, prepared aqueous extract by adding 225 g of sterile distilled water to 25 g of fresh sample, which was homogenized for 1 minute in a blender.

Table 7. Accumulated removed silage, daily removal layer, feed-out rate, surface area, and density of experimental silages

Item	SNAP6	SNAP9	SNAP12	SNAP15	WPCS15	SEM
Removed silage, kg	12810	11414	11061	11498	17279	24
Removal layer, cm/d	9.8	9.4	9.8	9.4	16.5	3.1
Surface area, m^2	4.5	4.7	4.2	4.5	3.2	0.5
Feed-out rate, $kg/m^2/d$	31.3	26.8	29.3	28.2	60.8	14.3
Density Top, kg/m^3	365.7	317	308.7	303.8	400.1	83.3
Density Middle, kg/m^3	419.6	403.5	364.2	374.5	459.9	83.3
Density Bottom, kg/m^3	476.8	444.4	430.7	425.7	520.3	62.9

After stirring, the extract was filtered through a cheesecloth gauze pad and sequential decimal dilutions (10-1 to 10-6) were performed for quantification of microorganisms by pour plate plating, in triplicate. From this extract, the pH reading was carried out in a digital potentiometer. The lactic acid bacteria (LAB) count was performed in an MRS culture medium supplemented with antifungal natamycin (0.25 g/L), after incubation of the plates under anaerobic conditions at 32°C (Biochemical Oxygen Demand (BOD) TE – 391 TECNAL incubation oven) for 48 h. The count of filamentous yeasts (LEV) and fungi (FUNG) was obtained from plating on Malt agar plus lactic acid at a concentration of 0.5%, with incubation of the plates in a BOD oven at 28°C, for 48 h for reading of yeasts and 5 to 7 days for reading of filamentous fungi. After the respective incubation times, microorganisms were counted on plates containing more than 10 and less than 300 colony-forming units (CFU) and expressed as a logarithm to base 10.

Table 8. Microbiology profile of experimental silages

Item	SNAP6	SNAP9	SNAP12	SNAP15	WPCS15
BAL, $\log_{10}$ CFU g/FM	4.12	3.56	4.34	5	4
Molds, $\log_{10}$ CFU g/FM	3.3	2.3	3	2.3	3.9
Yeast, $\log_{10}$ CFU g/FM	4.41	4.4	5.1	2.3	3

The aerobic stability (AE) of the silages was determined by controlling the temperature of the silages exposed to air, according to Kung et al. (2000). Three kilograms of silage was placed in plastic buckets without lids and without packing and kept in a room with an automatic device programmed to maintain an average temperature of 25 ± 1 ºC for 240 hours. Temperatures were measured every 30 minutes using an electronic system model Novus Tag Temp that was placed in the geometric center of the mass of each bucket. The variables analyzed were the aerobic stability of the silage, defined as the time that the silage mass takes to reach 2ºC above the ambient temperature, the maximum temperature reached by the mass, the time in hours to reach the maximum temperature, the accumulated temperature in 5 and 10 days of exposure to air. Each bucket was weighed 2 kg of silage (fresh matter) and after 10 days of exposure to air, the bucket with silage was weighed again to aim for the losses of fresh matter.

Table 9. Aerobic stability of experimental silages

Item	SNAP6	SNAP9	SNAP12	SNAP15	WPCS15
Aerobic stability, h	61±14	100±0.3	28±0.8	0	0
Temperature °C	32±0.7	25.79±0.58	32.30±0.21	35±18	33±0.2
Losses of FM, %	25.93	22.22	25.46	27.31	31.02

Figure 1. Dynamics of aerobic stability of SNAP 6

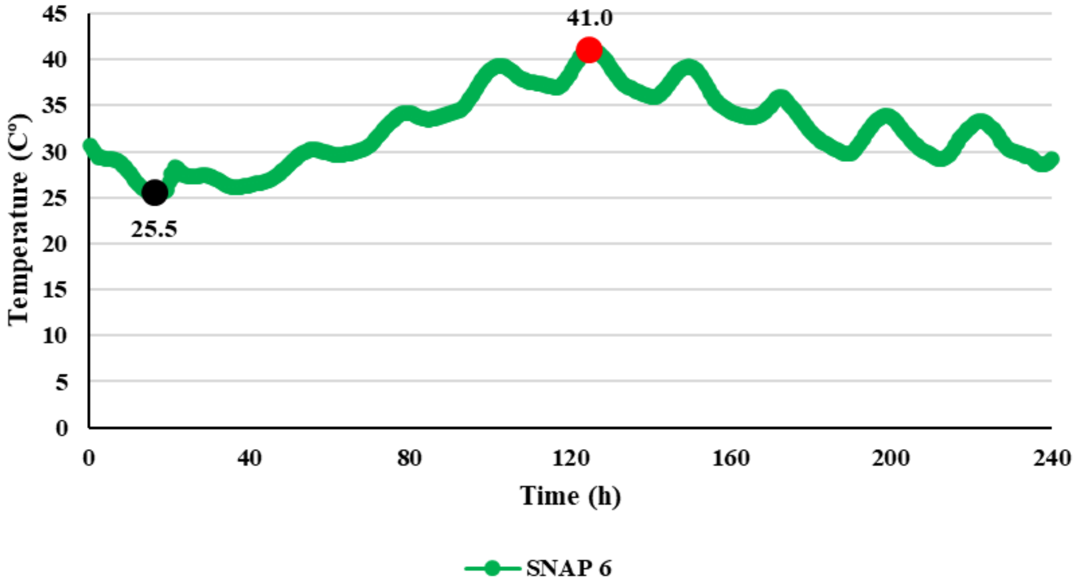


Figure 2. Dynamics of aerobic stability of SNAP 9

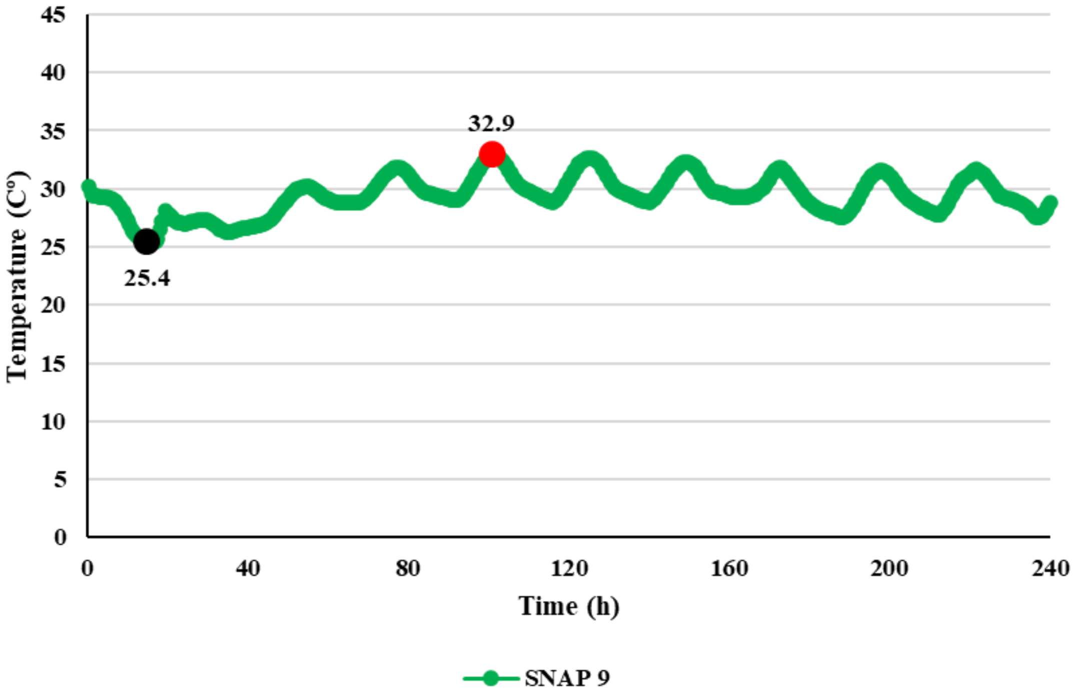


Figure 3. Dynamics of aerobic stability of SNAP 12

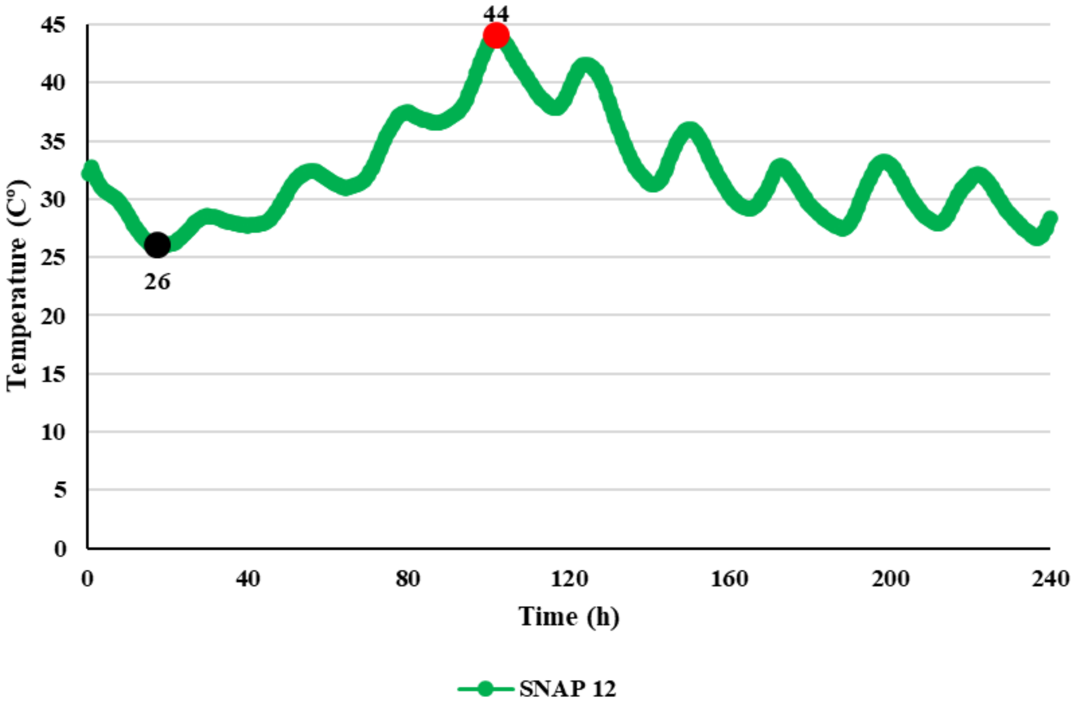


Figure 4. Dynamics of aerobic stability of SNAP 15

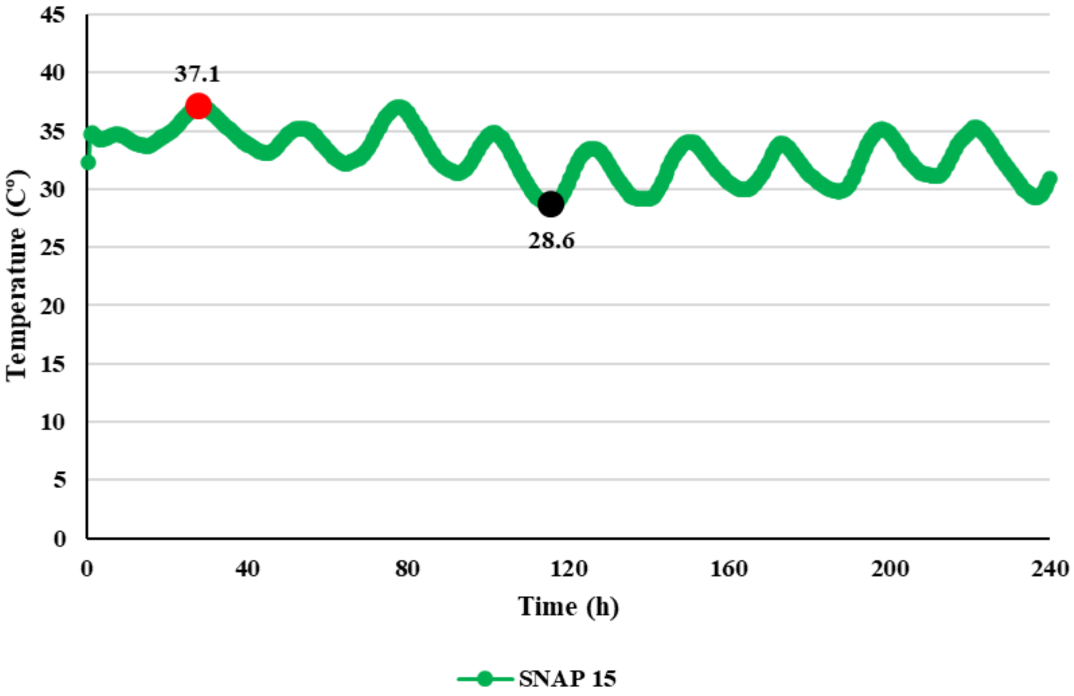
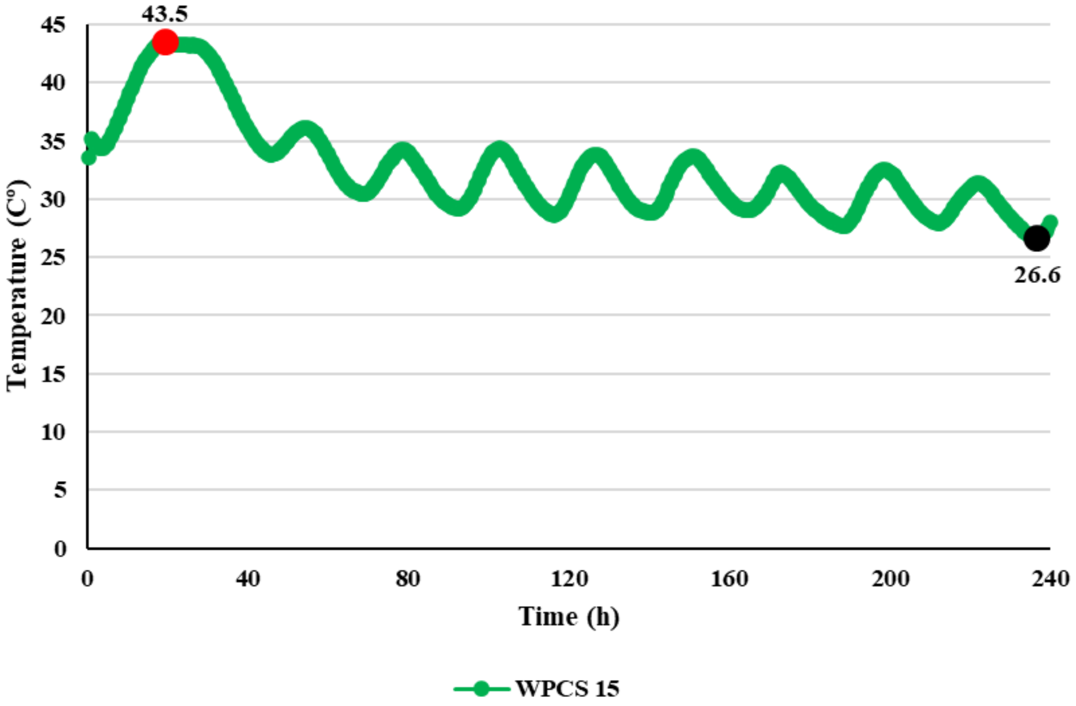


Figure 5. Dynamics of aerobic stability of WPCS 15



3.2.6. Statistical analysis

The statistical design for the animal performance was the randomized complete blocks, five treatments. The data were analyzed using the PROC MIXED procedure of SAS, with random effects for block, as follows the model structure: Yijk = μ + Bi + Dj + eij; where: μ = overall mean; Bi = random effect of blocks (i =1,2,3,4,5, …, 13); Dj = fixed effect of treatment (j = SNAP, WPCS); eijk = residual error. The experimental unit considered was the pen for all performance variables. For measurements in the experimental silos, descriptive measurements of mean and standard deviation were made in order to characterize the experimental silos.

4. RESULTS

Firstly, Table 10 shows the results of the bulls fed with experimental diets for the trial period. The DMI of the bulls was affected by the WPCS 15 (P = <0.001). But iNDF was affected by the treatments and WPCS 15 showed the highest intake of NDF (P = <0.001). Likewise, riNDF WPCS 15 showed the highest rNDF intake (P = <0.001) corroborated with Caetano et al. (2015) data. The daily variation was not affected by the experimental diets (P = 0.88). As a result, the feed efficiency was not affected by the experimental diets (P = 0.65). The WPCS 15 diet shows a tendency to higher ADG (P = 0.07), final BW of the bulls, carcass gain (P = 0.06) and income gain (P = 0.09). For iNDF and riNDF in SNAP 9 the lower content for this parameter (P = <0.001 and P = <0.001), probably was affected because of the NDF content of the silage (SNAP 9).

Table 10. Performance of the bulls fed with experimental diets in feedlot

Item	SNAP 6	SNAP 9	SNAP 12	SNAP 15	WPCS 15	SEM	*P-value*
DMI, kg/d	9.94b	9.58b	9.86b	10.34b	11.75a	0.47	<0.001
Daily Variation DMI, %	13.04	13.18	14.2	14	13.29	1.06	0.88
iNDF[1], kg/d	1.98ab	1.42c	1.91b	2.05ab	2.30a	0.085	<0.001
riNDF[2], kg/d	1.01b	0.80c	1.13b	0.99b	1.49a	0.047	<0.001
Initial BW, kg	399	400	396	397	399	16.41	0.84
Final BW, kg	541	524	542	524	559	19.82	0.07
ADG, kg/d	1.60	1.43	1.69	1.46	1.81	0.13	0.07
Carcass gain, kg/d	1.21	0.95	1.25	1.11	1.22	0.07	0.06
G:F[3]	0.157	0.141	0.154	0.151	0.155	0.007	0.65
Income gain, %	75.67	79.62	76.96	74.68	71.70	2.28	0.09

[1] NDF intake

[2] roughage NDF intake

[3] gain:feed ratio

In table 11 the data related to carcass evaluation such as dressing, 12th-rib fat, rump fat thickness, and LM area was not affected by the experimental diets. On the other hand, hot carcass weight was affected by the experimental diets (P = 0.01). For the energies, there isn't any difference among the diets (P = 0.11 and P = 0.24).

Table 11. Carcass characteristics of the bulls fed with experimental diets in feedlot

Item	SNAP 6	SNAP 9	SNAP 12	SNAP 15	WPCS 15	SEM	*P-value*
HCW, kg	308ab	286b	313ab	299ab	315a	12.54	0.01
Dressing, %	56.8	56.7	57.8	56.9	55.6	0.70	0.32
12th-rib fat, mm	4.32	3.76	4.72	3.59	4.73	0.41	0.10
Rump fat thickness, mm	6.45	6.15	6.77	6.51	6.59	0.41	0.87
LM area, cm^2	77.53	81.82	80.39	75.61	78.48	2.50	0.31
NEm, Mcal/kg[1]	2.22	1.92	2.09	2.03	1.98	0.08	0.11
NEg, Mcal/kg[2]	1.47	1.27	1.46	1.37	1.32	0.03	0.24

[1] Net energy of maintenance

[2] Net energy of gain

The data regarding the feeding behavior of the bulls fed with experimental diets are presented in Table 12. The bulls, which were fed the diet with WPCS 15, and others SNAP (6, 12, and 15) diets presented more time to rumination (P = 0.03), mastication (P = 0.04), and size of meal grams per MS per meal was higher to WPCS 15 diet (P = < 0.001) than SNAP 9, because of NDF content of the diet. For the SNAP 15 diet, the bulls were presented with a tendency to spend more time in 1^{a} meals (P = 0.06).

Table 12. Feeding behavior of the bulls fed with experimental diets in feedlot

Item	SNAP 6	SNAP 9	SNAP 12	SNAP 15	WPCS 15	SEM	*P-value*
Ingestion, min/d	188.77	180.69	178.46	180.85	166.38	11.38	0.73
Rumination, min/d	190.08ab	154.93b	187.22ab	187.22ab	224.67a	14.86	0.03
Mastigation, min/d	377ab	348b	384ab	365ab	418a	18.34	0.04
Mastication DMI, min/kg DM	36.44	41.8	38.06	37.5	37.81	2.63	0.56
1ª meal, min	41.52	38.59	38.38	46.95	35.81	2.84	0.06
Nº meal/d	5.5	5.7	5.7	5.2	5.5	0.2	0.80
Meal size g MS	1953.80ab	1591.25b	2059.70ab	2049.86ab	2299.78a	170.63	<0.001
Mealtime, min	34.46	33.6	33.41	34.54	31.15	1.99	0.73
Intermeal, min	231.97	224.5	230.76	244.88	244.16	8.39	0.28

Moreover, table 13 shows the sorting index of the bulls. For large particles above 19 mm, there was no intake preference. For particles above 8 mm, was intake preference for SNAP 6 diet and rejection for WPCS 15 diet (P = 0.03), probably the requirement of fiber was supplied by 19 mm pan. In addition, for particles above 4 mm and the bottom pan, there was no intake preference (P = 0.13 and P = 0.42).

Table 13. Sorting index of the bulls fed with experimental diets in feedlot

Item	SNAP 6	SNAP 9	SNAP 12	SNAP 15	WPCS 15	SEM	*P-value*
19 mm	119.28	117.48	121.93	118.17	112.41	3.57	0.41
8 mm	115.81a	108.18ab	104.27ab	111.67ab	92.11b	4.89	0.03
4 mm	103.17	104.36	105.85	100.08	111.28	3.03	0.13
Pan	81.72	86.25	88.78	90.09	85.4	3.62	0.42

5. DISCUSSION

The results presented the animal performance might not be affected by the different sources of roughage. Thus, the DMI was affected by the different roughage sources, animals fed diets with *snaplage* tended to intake less than animals fed with whole corn plant silage. The inclusion of 30% of *snaplage* in finishing diets does not differ among the *snaplage* treatments and the results of DMI observed in this trial corroborated with founded Salvo (2019). Probably, because SNAP has higher DM content than WPCS and greater starch digestibility for the *snaplage* and the higher DM content for the *snaplage* contributed to higher DMI for WPCS 15 treatment. Likewise, the increased intake leads to greater gut fill, but shorter digesta retention (Clauss et al., 2016). Intake of beef cattle fed with a high-concentrate diet is controlled by the energy demands of the animal, whereas for beef cattle the intake is controlled by physical factors, such as rumen fill (Allen, 2014; Goulart et al., 2020). In addition, forage type may influence the rate of breakdown of particles, so this difference in the rate of breakdown may have affected the retention time in the rumen and then the DMI in this trial (Huhtanen et al., 2016). Henceforward, the most used grain in Brazilian feedlots is flint corn which is characterized by lower starch digestibility due to the mainly vitreous endosperm (Correa et al., 2002) and the grain processing method influences the animal performance because the protein matrix surrounding the endosperm and the starch is not available to ruminal microbial to be degraded, therefore increase the surface area for bacterial and enzymatic digestion to enhance the animal performance is important to improve ruminal fermentability of grains (Ferraretto et al., 2013).

For ADG and final BW in this trial was presented a tendency for WPCS 15, SNAP 12, and SNAP 6 and this variation is due to the NDF roughage content in the diets being approximately 13%. According to Caetano et al. (2015), this parameter probably enhanced ADG, HCW, and final BW. The lower inclusion of SNAP in the diets is due to the high NDF content. Thus, the variation of NDF content in the crop probably decreased the ADG, HCW, and final BW of SNAP 9 and SNAP 15. The intake of NDF and rNDF differ among treatments and the highest intake of NDF for WPCS 15 (2.30 kg/d), probably enhanced the ruminal degradation and increased fermentation acids, and stimulated the chewing and rumination (Allen, 1997). Likewise, the cell-wall fraction of different roughage sources has been implicated as a control mechanism for forage intake, so the reduction in the concentration of cell-wall material may improve the energy density of the forage and would improve energy availability (Jung and Allen, 1995).

On the other hand, the theoretical length of cut (TLOC) nowadays is a tool wellestablished for improving physical and chemical characteristics and enhancing nutrient digestibility (Ferraretto et al., 2018). The main purpose of TLOC is to enhance silage peNDF content and properly peNDF is positively associated with chewing activity, and ruminal pH (Mertens, 1997). Higher peNDF is positively associated with sorting behavior. On the contrary, results shown by Leonardi and Armentano (2003) demonstrated that steers in feedlot commonly sort for the top sieve (19 mm), and in this trial, WPCS 15 the steers sorted negatively for the 8 mm sieve. Likewise, the digestibility of NDF was reduced by 0.61 percentage units as ruminal digestion and 0.48 percentage unit's as total tract per unit increase in dietary starch content (Ferraretto et al., 2013), but the feed efficiency was not decreased between the treatments. On the other hand, sorting behavior in favor of roughage is common for finishing beef cattle in a feedlot, mainly in diets with high content of concentrate (Caetano et al., 2015; Salvo et al., 2020), in finishing diets the bulls are willing for fiber to enhance the motility and buffer the acids in the rumen and increase the rumination and, hence, increase the salivation and increase the ruminal pH.

Even though the differences in TLOC were not related to performance parameters in this trial, the rNDF intake affected the performance parameters, instead TLOC. Experimental diets with approximately 13% rNDF showed better results than diets that did not match this level which agrees with Caetano et al. (2015). Probably, because of the physically effective NDF intake, in addition to the most important benefit of physically effective NDF is improving rumen health (Silva and Neumann, 2012). On the other hand, forage type may relate to the intrinsic characteristics' differences of fiber, likewise contents of cellulose, hemicellulose, and lignin, in addition, these characteristics might be strictly related to feeding behavior, rumen fill, and digestion kinetics, thus these variations in the number of fibrous carbohydrates can affect the roughage intake of the experimental diets (Palmonari et al., 2016).

Chewing time is a good parameter to predict rumen health, and animal performance, results presented in this trial indicated no difference between SNAP and WPCS diets related to chewing time, on the other hand, the most variation is correlated with rNDF presented in the diet, likewise in SNAP 9 diet which presented the lower rNDF content in whole treatments and affected the rumination time per day mastication time per day (154.93 and 348 min/d). Goulart et al. (2020) showed results that corroborated with results presented in this trial, the chewing time is similar for WPCS diets (428 vs 418 min), on the other hand, SNAP 9 treatment in which rNDF was 9.17%, demonstrated lower chewing and rumination times when compared with the other treatments (155 min).

Snaplage information is scarce, and still, there are a lot of unclear aspects of its utilization in diets. So many factors determine the quality of *snaplage*: hybrid; dry matter content; husks, cobs, shank, and grain proportion. Corn hybrids differ in proportions of floury and vitreous endosperm, in Brazil the most common commercial hybrids have vitreous endosperm (Daniel et al., 2019; Gusmão et al., 2021). Results shown by Gusmão (2021), which tested hybrids and maturity for *snaplage*, NDF content ranged from 20.6% to 21.9%, meanwhile, in this trial, the NDF content of the *snaplages* vary from 30.6% to 37.9% The increased level of *snaplage* NDF in the present trial might be a result of contamination with the upper part of the corn plant, mostly leaf and stalk, and this probably might be the reason for the lower nutritive value.

Typically, *snaplages* offer a dual contribution to diet nutrient profile, mainly NDF and starch content. The inclusion of only 30% of *snaplage* in the present diets is restrictive to find significant results on animal performance but was based on the NDF contribution from *snaplage* to match 20%NDF in the diet. In this trial, it was necessary to increase the amount of concentrate in the diet in order to supply the nutritional requirements of finishing cattle. We formulated for animals to gain 1.5 kg/d, and it was possible with a lower inclusion of *snaplage*, because the NDF content was higher than a typical *snaplage* (33.62% *vs* 21.53%), likewise NDF content found by Gusmão et al. (2021).

In order to enhance the digestion rate of *snaplage* nutrients might be achieved by more intensive processing of the cob, husks, shank, and grains. It is necessary to set the chop length as short as possible to maximize the bulk density and decrease as much as possible the losses of dry matter in the silo.

The Penn State Pan Separator quantifies the contribution of different fractions; however, the values obtained for *snaplages* samples in PSPS have shown an enormous variability and it might be a result of harvesting at different season crop, maturity stages, hybrids, or even the machine regulation on grabbing, by mistake, stalks, and leaves from the upper part of corn plants resulting in “contamination” (Mahana, 2008). The agronomic background of the corn crop might change dramatically the *snaplages* composition and then, the nutritive value as reported by Gusmão (referencia). Because of this, even though the data presented in this trial are similar to those reported by Salvo (2019), both differ from previous results presented by Akins and Shaver (2014). Literature is still scarce on the fermentation profile, microbiology, and aerobic stability of *snaplages*. For instance, the variation of starch content among the different *snaplages* might influence the fermentation profile, and this characteristic is affected by the microbiology population presented in the silage. Across maturity stages, not only the available sources of water-soluble carbohydrates (WSC), as fuel for fermentation, are changed, but also the profile of the epiphytic microbial population. *Snaplage* microbiome is modified accordingly with the morphological contribution in the plants, dry matter content, and water activity (Buxton and O'Kiely, 2003; Gusmão et al., 2021). In addition, aerobic stability is directly influenced by the microbial population, the prevalence of molds and yeast enhances the temperature in the silage, because of the degradation of WSC as substrate, and in the majority, these microorganisms are aerobic and release CO_2 and heat throughout the typical respiratory pathways. In a review, Borreani et al. (2018) reported lower yeast count is associated with higher aerobic stability. In addition, SNAP 6, SNAP 12, and WPCS 15 presented higher counts of mold; thus, mold content may have contributed to the deterioration of these silages. The reason for a lower amount of mold in the *snaplage* is the lower water activity, because of the high DM content of the *snaplage* and this characteristic may reduce the development of those microorganisms, thus reducing the spoilage.

Another good indicator of a good silage fermentation is the pH which indicates a proper fermentation profile. High WSC content is metabolizable in organic acids by microorganisms and the major acid concentration in the silages is lactic acid which presents a higher p*Ka* (3.86), thus contributing the most to the decline in pH during fermentation (Kung et al., 2018). Typical acid lactic concentrations range from 2 to 4%, but in drier silages, likewise, *snaplage* has a lower amount of lactic acid (1.98%) than WPCS (2.24%) which may spoil quickly when exposed to air and another reason is these silages tend to be more porous, moreover the different TLOC may influence in the amount of spoiling, SNAP 15 have the lower packing density (425.73 kg/m^3) among the treatments which contributed on spoilage content. When silage is exposed to air, thus oxygen allows aerobic microorganisms to consume WSC readily, causing DM losses (Borreani et al., 2018). Another parameter that influences aerobic deterioration is the feed-out rate, according to Bernardes et al. (2021) a good feed-out rate is 250 kg/m^2, but results presented in this trial showed a huge difference in the preconized feed-out rate and the observed for *snaplages* we founded values which vary among 26.8 to 60.8 kg/m^2, probably this great difference may influence in the quality of silage after opening the silo to fed the animals, otherwise the results of ADG, HCW, final BW has shown the animal performance wasn't affected by the quality of silages.

Packing density is another important parameter to indicate good silage because the porosity decreases when increased packing density. High porosity allows penetrating air inside the silo and increases aerobic deterioration. Furthermore, DM losses have a high correlation with packing density (Köhler et al., 2013; Borreani et al., 2018). Thus, the packing density recommended is around 705 kg/m³ for WPCS and SNAP is recommended 560 kg/m³, even though the packing densities found in this trial indicate a lower packing density than a recommendation for SNAP founded values among 425.7 to 476.8 kg/m³ and for WPCS founded 520.3 kg/m3, probably due to the DM content of *snaplage* being higher than WPCS and this effect in the process of packing.

Another main reason is the fermentative profile of the experimental silages, results found in this trial are very similar to results presented by Gusmão et al. (2021) for lactic acid, instead for acetic acid was very different, probably the LAB in charge of the fermentation are heterofermentative strains which are responsible to produce acetic acid. The lower aerobic stability of the experimental silages is associated with the high yeast and fungi count, probably after the opening of the silo, because the lower packing density allowed the input of oxygen in the silage contributing to the increment of undesirable microorganisms, thus causing the lower aerobic stability of the experimental silages.

On the other hand, one point to highlight is the content of 1,2 PD (1,2-propanediol), is very related to the production of glucose in the liver of the ruminant or propionic acid in the rumen, but the lower content of this compound is associated with the high content of *L. buchneri* and *L. diolivorans* (Kung et al., 2018) which may explain high content of acetic acid in the silages and the aerobic stability is related with the fermentative profile and the *snaplage* was presented the high aerobic stability is SNAP 9 (100±0.3 h) which presented the high content of acetic acid of the experimental *snaplages* tested in this trial.

The main purpose of this trial was to identify if different TLOC of *snaplage* should affect the performance of finishing bulls in the feedlot, but the observed particle size is not what we expected and does not differ much among the treatments. The lack of information about MPL and PSPS distribution for *snaplage* makes it difficult how to explain the results found in this trial, according to Shinners (2003) the TLOC is controlled by the peripheral speed of the feed rolls, the number of cutter head knives, in addition, the only way to change TLOC is altering the peripheral speed of the feed rolls (Shinners, 2003; Salvati et al., 2021). On top of that, we observed major differences among longer particles (> 19 mm and > 8 mm), Johnson et al. (2003) reported increments of MPL and the percentage of longer particles in response to different TLOC settings for WPCS in self-propelled forage harvester, in contrast, our results shown no significant difference among the treatments in the percentage of shorter particles (< 4 mm) for SNAP, the major difference was between SNAP 6 and SNAP 12 (19.6 and 15.8%) particles retained in the bottom pan and this factor may contribute for small differences among MPL observed in this trial.

6. CONCLUSION

The different TLOC of *snaplage* does not affect the performance of the bulls in the feedlot, instead rNDF available in the diet contributed to higher ADG numerically for SNAP 6, SNAP 12, and WPCS 15 than SNAP 9 and SNAP 15 treatments. Because of the small variation among this range of MPL (6.6 to 7.4 mm) of *snaplage*, it is not provided by a difference in the performance of beef cattle in the feedlot. In addition, *snaplage* as the only source of roughage might replace WPCS in finishing diets of beef cattle in the feedlot. Thenceforward, more studies are necessary in order to enhance the technology used during the *snaplage* harvest.

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