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The use of essential oils as an alternative to performance-enhancing antibiotics in beef cattle: Literature review

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ABSTRACT
Brazilian livestock farming stands out worldwide as a leader in the production and export of meat, driven by a significant herd of approximately 234.4 million head, according to IBGE data from 2023. The beef cattle production cycle comprises three distinct phases: breeding, rearing and finishing, each culminating in the production of weaned calves, lean steers and fat steers, respectively. This activity, predominantly based on pasture due to tropical climatic conditions, faces challenges such as pasture degradation and forage seasonality, requiring the use of technologies such as growth-promoting additives to optimize production results. These additives, including antibiotics such as ionophores and non-ionophores, as well as essential oils, improve feed efficiency and contribute significantly to the national economy, although they raise debates about microbial resistance and environmental impacts.

Keywords: Cattle, Ionophores, Non-ionophores, Nutrition, Essential oils.

INTRODUCTION

Brazilian livestock has been standing out among meat-producing countries, with the country being the largest exporter of meat according to the United States Department of Agriculture (USDA) presenting expressive numbers such as a herd estimated at approximately 234.4 million head, disclosed in the Municipal Livestock Survey (PPM) published on September 21 (twenty-one) 2023 by the Brazilian Institute of Research and Statistics (IBGE), thus securing the position of the second largest producer.

Briefly characterizing the Brazilian beef cattle breeding, the production cycle comprises the rearing, rearing and finishing phases, being the product of each of them respectively: the weaned calf, the lean cattle (animal from 02 months that will follow until 15 (fifteen) to 16 (sixteen) months in a fattening regime) and the fat cattle (product for sale between four hundred and eighty to five hundred kilos) (BARCELLOS, 2011; LAZZARINI NETO, 1994). This entire period of animal development corresponds

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to an interval between 02 and 05 years, according to MARION; SEGATTI, 2012, and it is therefore essential to use technologies to optimize the result of this production.

Knowing that 90% of the rearing takes place in pasture systems, balanced nutrition composed of products that implement weight gain is necessary, since the pastures of the Brazilian territory are mostly degraded and in need of management, fertilization and soil correction, in addition to the seasonality of forage since we are in a tropical country (REIS and SILVA, 2006). Thus, investments in genetics and formulations with performance-enhancing additives can increase zootechnical indexes, either by providing greater weight gain and carcass yield, or by maintaining the weight gain pattern or modulating the rumen environment (DIAS, 2016).

Performance enhancers or growth promoters, as they are commercially known, provide, in addition to all the increase in feed efficiency and conversion, savings in the costs of herd nutrition Oliveira et al, 2005. This fact has a direct impact on the economy since in 2022, the foreign exchange revenue from meat exports was 11.8 billion dollars from 1.98 million tons exported, even with all the difficulty of the current scenario (FERREIRA, 2023).

The most commonly used growth promoters are mostly antibiotics, separated into two classes: ionophores and non-ionophores, as well as essential oils, tannins, saponins, adsorbents and yeasts. Examples of the first class of antibiotics are: monensin, salinomycin, narasin and lasalocid, and the second, virginiamycin. These additives modify the ruminal dynamics and allow better use of the total ration. (COSTA, 2021).

This expanded summary aims to establish a comparison between antibiotics and essential oils, based mainly on the class of ionophores, especially sodium monensin, and non-ionophores, especially virginiamycin in cattle.

MATERIALS AND METHODS

This abstract is based on a literature review, case studies and research projects described in theses and dissertations on the use of growth promoters in the nutritional management of Brazilian beef cattle.

FINDINGS

In order to supply nutrients from the animals' diet and aiming at a better zootechnical and health performance, the use of feed supplementation for beef cattle has become frequent, through products formulated with growth-promoting additives added to roughage or concentrates, whether mineral, protein or protein-energy (ASBRAM, 2007). The explanation for this increase in the use of technological products lies in rumen biochemistry, which gives ruminants the ability to digest fibers (Russel and RICHLIK, 2001) through microorganisms that secrete enzymes that degrade this fiber and, therefore, supplementation with fast fermentation feeds favors the increase in the efficiency of ruminal nitrogen capture from forage. in addition to the factors directly linked to productivity such as increased microbial protein and effectiveness of the undegraded protein passage rate in the rumen (RDP), propionate and total fatty acid production (HOOVER, 1986), which confer muscle growth and carcass finishing faster as expected by the market (CHARDULO, 1998).

Morais et al, 2011 highlight as benefits of the use of additives the possibility of maximizing feed efficiency by reducing losses of methane, heat and ammonia to the environment and, consequently, the animal saves energy and proteins with this reduction of rumen losses. In the case of growth promoters in the ionophore category, their addition to supplementation aims to mitigate mortality through the prevention of infectious and parasitic pathologies, in addition to preserving the organoleptic properties of the feed and of the meat itself (PALERMO NETO, 1998).

These additives described in this review, according to MAPA, belong to the category of zootechnical additives, which have a positive influence on the use of food and health, and are grouped in the functional group of performance enhancers where ionophores, non-ionophores and essential oils are allocated. The additives of this group are responsible for providing answers to the questions of expected results in financial and performance terms, directly correlating with the composition and processing of the diet, thus ensuring digestibility, consumption and energy efficiency (VAN SOEST, 1994).

Ionophore additives get their name due to their property of altering the flow of ions across the cell membrane, acting in such a way as to selectively inhibit microorganisms due to the change in osmolarity (BERCHIELLI, 2010).

According to Freire et. Al, 2019, the mode of action of ionophores occurs through interference in the growth of Gram-positive bacteria in favor of Gram-negative bacteria, in addition to regulating the chemical balance of intra and extracellular media, acting by the balance called cation pump. This is because Gram-negative bacteria have a liposaccharide layer that associates with hydrophilic protein channels (porins), whereas in Gram-positive bacteria this layer is absent. These protein channels, porins, have a size above 600 Daltons, which explains the ineffectiveness on the gram-negative group because ionophores have a larger molecular size (SILHAVY, 2010). The most commonly used are momensin, which has a size of 671 Daltons, followed by lasalocid with 591, salinomycin with 751 and narasin, more commonly used on pasture, with a size of 765, all of which are highly hydrophobic, not exceeding porins (NOVILLA; Mcclary; LAUDERT, 2017).

Because they are ruminal pH buffers, ionophores act by reducing protein degradation in the rumen microbiota and reducing lactic acids, improving energy efficiency (THOMPSON et al., 2016), being ineffective in feed management composed of foods with low fermentable fiber content (RANGEL, 2008).

Regarding the mode of action of non-ionophore antibiotics, virginiamycin can be mentioned, as it is the most widely used in Brazil (LANNA; MEDEIROS, 2007). It establishes an indissoluble bond with ribosome subunits, leading to cell lysis by preventing peptide bonds from occurring during protein synthesis, thus promoting ruminal fermentation stability and improving weight gain and feed efficiency, due to the fact that it alters the rumen bacterial population (PHIBRO, 2015). Compared to ionophores, it becomes more effective in the synthesis of lactate, reducing the incidence of acidosis and increasing energy efficiency, being demonstrated by the lower number of lactic acid-secreting bacteria presented. (NUÑEZ et al, 2013).

The great discussion for the replacement of antibiotics by more natural alternatives is due to the controversy over microbial resistance, which discusses the creation of resistant strains due to the indiscriminate use of these additives (COPPOLA AND TURNES, 2004). However, authors disagree with the occurrence, as is the case of PHILLIPS et al, 2004, which correlates it to the indiscriminate use of antibiotics by humans and not effectively to their inclusion in cattle feed.

Emerging as a healthy and residue-free alternative, essential oils are being researched as substitutes for antibiotics in animal nutrition, (JORGE et al, 2006; PATRA, 2010).

Possessing an extensive diversity of active ingredients, essential oils are compounds extracted from plants (stems, leaves, flowers, bark, roots) and have antioxidant, anti-inflammatory and antimicrobial action, indicating that, if supplied in adequate dosage, it tends to modify ruminal fermentation of ruminants in a positive way, with the reciprocal of overdosage being harmful to the rumen microbiota (SILVA, 2014). Its form of action is similar to ionophores, acting more specifically on gram-positive bacteria, but its efficiency on the gram-negative group has been demonstrated in rumen environment tests (CARDOZO et al., 2005; CASTILLEJOS et al., 2006; Busquet et al., 2006). As the extraction of the active ingredient takes place through plant processing, several factors influence the composition of the essential oils, such as maturation, extraction method, thus making it impossible to correctly determine the recommended dose. (BURT et al 2004; ARAUJO, 2010).

Provenza, 2010 points out that diets rich in concentrates, where the pH is lower, potentiate the effect of essential oils, since the interference of the rumen environment in the mechanism of action. An obstacle to the use of this type of additive is the partial degradation of its properties by the rumen microbiota and the taste and odor that could affect ingestion, negatively influencing palatability, in addition to the volatility of these compounds making them susceptible to being eructed. (ARAUJO, 2010; MAROSTICA JR, PASTORE, 2007).

A literature review carried out by Araújo, 2010, highlights the use of essential oils in the diet of ruminants as a way to combat rumen acidosis, anthelmintic, insecticidal and antioxidant action, in addition to influencing foodborne pathogens. As for the possible carcinogenic, phototoxic and mutagenic effects, warned by Bakkali et al., 2008, as well as the interaction with the nervous and reproductive systems, high doses are necessary to obtain them.

FINAL CONSIDERATIONS

The use of essential oils as an alternative to replace antibiotics as growth promoters in animal nutrition requires further studies, since in *vitro* experiments have been shown to be satisfactory, but without effective *in vivo* proof, indicating the need to establish more effective dosages and active ingredients to meet the needs of each animal category.

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