



Benefits of eating meat sheep to human health

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ABSTRACT

This work aims to analyze the dietary influence on animal health, its effects on meat quality and carcass characteristics, and the benefits of meat sheep consumption for human health. A search was conducted for articles published between 2000 and 2023 in the primary scientific bases in which the theme aimed at the relevance of sheep farming combined with animal nutrition and management. Although sheep production occurs throughout Brazil, it is still not exploited efficiently, and sheep meat consumption is still associated with special occasions. Its commercialization. Nutrition is one of the main factors that influence the quality of meat, and the use of natural alternatives such as essential oils and plant extracts, which improve color and aroma and guarantee longer shelf life, has been increasing. In addition, the use of lipid sources in the diets of small ruminants improves the lipid profile of the products, decreasing the amount of saturated fatty acids and increasing the content of monounsaturated and polyunsaturated fatty acids, which are associated with the prevention of various types of cancer and diseases. The heart also improves immunity. Consumers are increasingly concerned about their health and more demanding about food quality, so the meat industry must pay attention to consumer perceptions and preferences to meet market demands.

KEYWORDS: Consumer. Nutrition. Sheep farming.

1 INTRODUCTION

Meat and its derivatives are important elements of the human diet because they provide essential nutrients that are not easily obtained through the ingestion of vegetables and their derivatives (SULEMAN et al., 2020). In the last 20 years, the demand for meat products has increased worldwide, leading to the development of bovine and other ruminant production to supply this demand (SANS; COMBRIS, 2015; CHIKWANHA et al., 2018).

Food has a fundamental role not only in nutrition and personal satisfaction but also in the evolution of societies, dictating dietary models and eating patterns. When we look closely, we observe the various changes over time in these models in different countries (COMBRIS; SOLER, 2011).

As the income per capita increased, there was a nutritional transition characterized by caloric saturation, so meat became an expensive food and, consequently, plant-based foods partly replaced traditional foods (BAKER et al., 2020). In fact, meat consumption has increased worldwide from 23.1 kg per person-year in 1961 to 42.2 kg per person-year in 2011. Developed countries have achieved average levels of animal protein consumption that exceed needs, noting that: as income increases, the proportion of food expenditure on protein increases concomitantly (REGMI; TAKESHIMA; UNNEVEHR, 2008; SANS; COMBRIS, 2015).

Like other ruminants, sheep meat is a source of n-3 polyunsaturated fatty acids (n-3 PUFAS), branched-chain fatty acids (FA) and PUFA biohydrogenation intermediates (PUFA-BHI), conjugated linoleic acids, trans-octadecenoic acids, which exhibit potential beneficial effects on human health (DILZER; PARK, 2012; RAN-RESSLER et al., 2014). In addition to having health effects, fatty acids play an essential role in the texture, flavor, aroma, and acceptability of the product by the consumer (WATKINS et al., 2014).

There is a tendency on the part of the scientific community to develop meat products with a higher content of "good fats", in this direction, sheep meat production has the potential to provide foods enriched with fatty acids for human health since the diet provided to ruminants is the main factor that influences the fatty acid profile (DE SMET; VOSSEN, 2016). Unfortunately,

the relationships between sheep meat fatty acids and their effects on human health are not well documented and need further study.

2 OBJECTIVES

This review analyses the dietary influence on animal health and its effects on meat quality and carcass characteristics, as well as the benefits of sheep meat consumption for human health.

3 METHODS

This study is a qualitative literature review conducted through searches in the main scientific databases (Scopus, Google Scholar, Scielo, and Web of Science), books and articles hosted on websites related to the theme.

Keywords were searched individually and combined in the period from 2000 to 2023 in English, Portuguese, and Spanish, which addressed the following topics: quality of sheep meat and its benefits for human health. Subsequently, a pre-selection was realized based on the analysis of the abstracts. The exclusion criteria were articles that did not fit with the date (except with high scientific relevance), language, and with the established theme. Data analysis and graphics elaboration were performed in the R statistical software (R CORE, 2021).

4 RESULTS

4.1 Sheep Meet Production

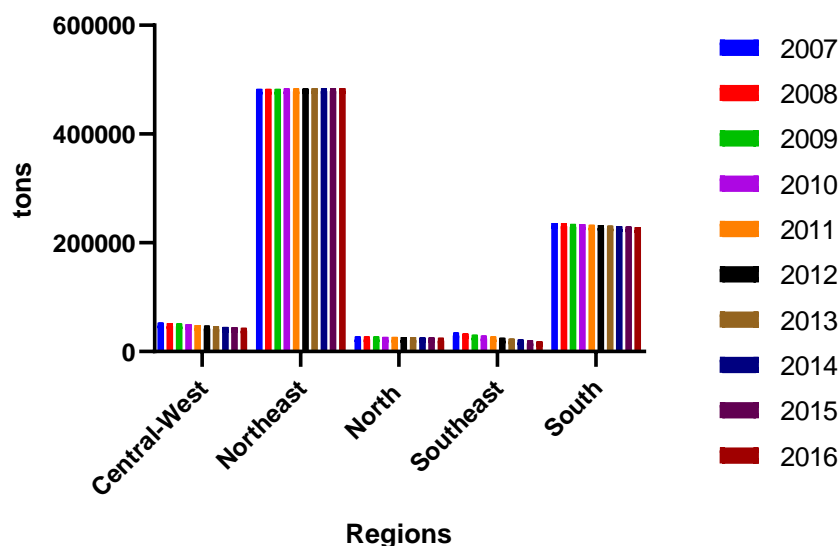
In Brazil, there are more than five million agro-livestock establishments, where 10.4% work with sheep farming, with a herd of 14 million animals, making the country the 10th with the largest sheep herd in the world (FAO, 2019; IBGE, 2020). Over the years, mainly due to the decrease in rural population and, consequently, the available labor force added to the changes in production systems with the increase of soybean and forestry crops (MATTE et al., 2019; MATTE; WAQUIL, 2020; MOREIRA; CONTERATO, 2019), there is a reduction in establishments that produce sheep. In the period from 2006 to 2017, the number of establishments with sheep production decreased by 9.4%.

China currently leads as the largest importer of sheep meat, while Australia stands out as the main exporter of this product. It is interesting to note that, since 2013, Brazil has not registered significant exports in this sector and over the decades from 1990 to then, there has been a downward in exports (FAO, 2019; MATTE; WAQUIL, 2021). In the case of the wool industry, there was a prosperous period until the early 1980's, when the lack of government initiatives and the global crisis in the price of wool gradually drove the replacement of this material with synthetic alternatives. These changes resulted in a considerable reduction of the sheep herd in Brazil, especially in the state of Rio Grande do Sul (NASCIMENTO et al., 2018).

Although the sheep production chain faces numerous challenges, the most part of the herd is concentrated in small family properties and in the Northeast region of Brazil and

according to the latest agricultural census indicates growth in production, as shown in Figure 1 (MAGALHÃES et al., 2017; EMBRAPA CAPRINOS E OVINOS, 2019).

Figure 1 - Sheep meat production (tons).



Source: Embrapa Caprinos e Ovinos (2019)

Lamb production can be found almost all over Brazil, with a significant number of producers, especially on family farms. However, this activity has not been explored yet, in an efficient and competitive way (BATTAGIN; PANEA; TRINDADE, 2021). Despite the favorable climate and the availability of highly productive pastures, the shortage of lamb supply results in the necessity of importing sheep meat, mainly from Uruguay, Chile, Argentina and New Zealand (MAPA, 2015).

The use of different production systems in sheep farming results in a variety of options, which influences the intrinsic and extrinsic characteristics of sheep meat (PRACHE; SCHREURS; GUILLIER, 2022). In Brazil, sheep production is predominantly conducted in pastoral systems, using dual-purpose breeds and commercial flocks for meat production (RICARDO et al., 2015).

Lamb meat is obtained from the slaughter of animals up to one year of age, being recommended between four and six months, with an average weight ranging from 25 to 35 kg. It stands out for having a lower fat content than beef and pork and for being a rich source of vitamins, proteins and minerals. The most common cuts of lamb meat include leg, shoulder, rib, loin and rack, and are used in traditional dishes such as "carreteiro" rice, a casserole dish (escondidinho), stews and barbecue (EMBRAPA CAPRINOS E OVINOS, 2019).

Despite these positive characteristics, sheep meat consumption in Brazil is still considered low, usually limited to celebrative occasions. This is due, in part, to the lack of familiarity of Brazilians with this species and the lack of information on consumers' perception of lamb meat (ANDRADE et al., 2016; BATTAGIN; PANEA; TRINDADE, 2021).

The production of adult sheep includes several steps, from the careful selection of

breeding stock to the implementation of adequate nutritional management, health care and reproductive management. In choosing breeding stock is essential to consider aspects such as prolificacy, maternal ability, conformation and meat production capacity (RAINERI; NUNES; GAMEIRO, 2015; SILVEIRA et al., 2021).

To maintain productivity, sheep can be disposed of for various reasons, such as old age, low productivity, chronic health problems, or injuries that compromise their quality of life. In a sheep flock is recommended a percentage of disposal is around 10% to 20%. These animals can be directed to slaughter, aiming at the production of meat or other by-products (MATTE; WAQUIL, 2021).

4.2 Feed and diets used in sheep farming in Brazil

4.2.1 Pastures

The utilization of pasture systems with forage grasses has presented satisfactory results. Combining the high biomass production per unit area, the nutritional value of the forage and low production cost has become interesting to the producer (MELO et al., 2016). The better use of the pasture influences the feeding behavior of the animals, resulting in a higher intake of nutrients (YILDIRIM et al., 2017).

In the Brazilian Northeast, pasture has been used as one of the components of the diet and the changes in the characteristics of these forages throughout the year influences directly the performance of the animals (SOUZA et al., 2019). Another essential forage component in the region is the forage palm (*Opuntia ficus-indica* (L.) Mill), an energy food due to the high concentration of non-fibrous carbohydrates, 534 g/kg of dry matter (PESSOA et al., 2020), 2020), this plant presents satisfactory production with the use of minimal inputs and has resistance to drought, due the physiological mechanism, Crassulacean Acid Metabolism (CAM), which is characterized by the opening of stomata and CO₂ capture during the night, when the temperature is lower and the humidity higher than the day (HASSAN et al., 2019).

In the Southern region, subtropical pastures are characterized by two distinct sets of forage species, those that grow in the warm season and another that grow in the cool season (POLI et al., 2020). This requires different technology for each season, planning on the producer's part, and understanding the animal/environment dynamics.

In subtropical areas, it is possible to raise lambs on temperate, tropical or both types of pastures. This pasture growth is associated with the relatively high rainfall in southern Brazil, 1200-2100 mm, distributed throughout the year (WREGGE et al., 2018). This fact confers a great advantage for the production of fodder at low cost.

4.2.2 Dietary additives

The use of antibiotics as feed additives in ruminants, including ionophores such as monensin, lasalocid and sonilomycin, has been reduced due to the risk of residues in products such as meat and milk and the possibility of promoting bacterial resistance in certain strains (MORSY et al., 2016). As a result, the use of these additives has been banned in the European Union since 2006.

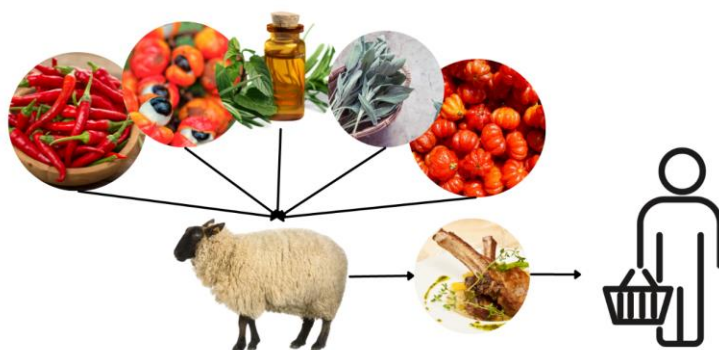
In this context, several natural alternative feed additives have been explored, such as

propolis, essential oils, plant extracts, plant by-products and probiotics. These substances have been used as substitutes for antibiotics, aiming to improve animal performance and promote intestinal health in a safer and more sustainable way (MORSY et al., 2016).

In studies conducted, it was found that the dietary addition of propolis resulted in improvements in performance and carcass quality of bulls finished in feedlot (ZAWADZKI et al., 2011). In this context, propolis extract has been used as a feed supplement to replace monensin sodium in diets of confined lambs (ÍTAVO et al., 2011). Due to its antimicrobial properties against gram-positive bacteria, propolis also shows promise as an additive capable of modifying microbial fermentation in the rumen (MORSY et al., 2021).

Consumers are becoming more conscious of the safety and benefits of plant extracts, recognizing them as important antioxidants, which has led to their inclusion in several meat products (MUNEKATA et al., 2020), as illustrated in Scheme 1. Polyphenols, such as anthocyanins, tannins and flavonoids, together with essential oils, are examples of bioactive compounds found in different parts of plants such as seeds, leaves and fruits and have been widely used in the meat industry (HU et al., 2018).

Scheme 1 - Use of plant extracts in sheep nutrition and their benefits in the consumer's view.



Source: the author himself (2023)

Meat products that are cooked above 150°C can produce harmful products due to reactions between creatinine, amino acids and sugars, these compounds are called heterocyclic aromatic amines (JOHN; BEEDANAGARI, 2014). In this context, Suleman et al. (2019) observed the influence of the spices, ginger, cinnamon and "Chinese prickly ash" and noted an inhibition of amines because of their antioxidant activity.

Essential oils are natural products extracted from a wide variety of plants, many of them known for their antioxidant and/or antimicrobial properties. In recent decades the food industry has increasingly realized the potential of these compounds (ADELAKUN; OYELADE; OLANIPEKUN, 2016). These phytochemicals benefit directly the animals that consume them and also have an indirect impact on meat quality (KUMAR et al., 2015).

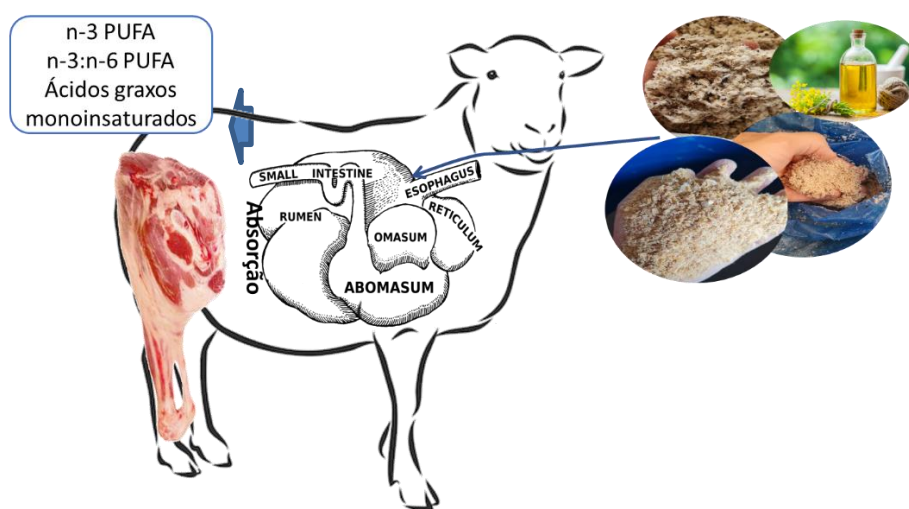
Studies have been showing the positive effects of essential oils on meat. For example, the use of oregano essential oil resulted in higher fatty acid concentration in meat (GARCIA-GALICIA et al., 2020). Further, supplementation of sheep with *Ferulago angulata* essential oil at doses up to 750 ml/kg dry matter was associated with improvements in meat chemical composition and increased antioxidant status, without adverse effects on physical parameters (PARVAR et al., 2018). These findings highlight the potential of essential oils as natural additives in quality meat production.

4.2.3 Lipid sources

Ruminant meat consumption is declining in Europe and North America, driven by health concerns related to the high content of saturated fatty acids found in these products. In order to provide meat that promotes human health benefits, strategies have been developed to produce leaner meats with lower fatty acid content and higher monounsaturated fatty acid and polyunsaturated fatty acid content, in particular n-6 and n-3 polyunsaturated fatty acid (FACCIOLONGO et al., 2018; VAHMANI et al., 2015). These fatty acids are associated with the prevention of several types of cancer and heart diseases and in improvement of the immune system and overall human health (MOLONEY; SCOLLAN; MILES, 2008; SCOLLAN et al., 2014).

Recent studies have focused on increasing the content of n-3 polyunsaturated fatty acid and conjugated linoleic acid in ruminant products (ALBA et al., 2021; GALLO et al., 2019; KANDI et al., 2020; PARENTE et al., 2020; SILVA et al., 2022). However, dietary supplementation to increase the amount of desirable lipids in sheep meat faces challenges due to the ruminal biohydrogenation of fatty acids which is influenced by the bulky feed:concentrate ratio, oil level and type, rumen pH and additives (BESSA et al, 2000; DEN HARTIGH, 2019), as illustrated in Scheme 2. Therefore, it is crucial to deepen the knowledge of these factors and to carry out continuous research aimed at optimizing the production of sheep meat with healthier fat profiles, meeting the demands of health-conscious consumers.

Scheme 2 - Inclusion of lipid sources in sheep diets and their benefits on meat quality.



Source: the author himself (2023)

The main sources of supplemental fatty acids present in ruminant feeds are vegetable oils, oilseeds, fish oils, seaweeds and fat supplements. Dietary inclusion is limited to approximately 60 g/kg dry matter. Despite rumen biohydrogenation, a proportion of dietary polyunsaturated fatty acid bypass rumen metabolism passing undamaged, being absorbed and deposited in body tissue (SHINGFIELD; BONNET; SCOLLAN, 2013).

In order to increase the concentration of polyunsaturated fatty acid in sheep meat, Valença et al. (2021), included in the diet of Ile de France lambs up to 6% of seaweed meal (*Schizochytrium* sp.) and observed and the increase in the concentrations of long-chain polyunsaturated fatty acids eicosapentaenoic (C20:5 n-3), docosaenoic (C22:5 n-3) and conjugated linoleic, a 5.6-fold increase in the sum of omega-3 and a reduction in total cholesterol in meat, thus improving the nutritional quality of lamb meat fat.

In the Ladeira et al., (2012) review, the effect of dietary supplementation with vegetable oils was observed where supplementation with flaxseed or linseed oil (rich in 18:3 n-3) can increase the concentration of 18:3 n-3 in meat with desirable decrease associated with n-6:n-3 polyunsaturated fatty acid. Similarly, it has been found that sunflower seed or sunflower oil (rich in 18:2 n-6) can increase 18:2 n-6 deposition in muscle tissue, but with a possible increase in n-6:n-3 polyunsaturated fatty acid content. Polyunsaturated fatty acid supplementation generally causes a small but statistically significant decrease in the proportion of monounsaturated fatty acid (MOLONEY, 2011).

Another way to make dietary fat available is to protect the lipid from rumen degradation. This can be achieved through intact oilseeds, heat/chemical treatments of intact and/or processed oilseeds, chemical treatments of oils to form calcium soaps or amides, emulsification/encapsulation of oils with proteins and subsequent chemical protection. Physical treatment methods do not increase the proportional loss of polyunsaturated fatty acid in the diet, but may increase the amount of polyunsaturated fat that escapes from the rumen in cattle when supplemented (GULATI et al., 2005).

In the Alba et al. (2021) study, where the inclusion of protected and unprotected fats in the diet of confined sheep was evaluated, they concluded that the inclusion of 3.5% calcium salts of fatty acid as a source of protected fat in the total diet of confined lambs results in higher slaughter weight, carcass weight and yield, conformation, finish, compactness index and loin eye area of the carcass. And there was an improvement in the lipid profile of the meat, especially the bioactive ones relevant to human health.

When evaluating lambs fed with almond hulls (15% and 30% of the concentrate DM), Scerra et al. (2022) noted that the diets did not influence the final weight of the animal, nor the consumption of dry matter and carcass weight. Costa et al. (2018) observed that lambs consuming diets containing 0, 8, 16 or 24% of licuri cake (16.1% crude protein and increasing levels of ether extract as the addition of the cake increases, averaging 3.85%) were not affected by pH, tenderness, cooking loss or shear force, but there was a linear decrease ($P < 0.01$) in redness, chroma, lipids, protein content, while meat moisture ($P < 0.01$) increased linearly due to the inclusion of the cake in the diet.

4.2.4 concentrated feeds

The confinement of sheep attracts great interest among farmers, as it offers several advantages, such as reducing losses of young animals due to nutritional deficiencies and parasitic infestations, thus ensuring a regular supply of animals to the market (DE MEDEIROS et al., 2009). Pasture supplementation can play an important role in improving rumen pH, digestion and growth in sheeps. However, it is necessary to consider the substitution effect that occurs in many cases, where animals start to consume more concentrate to the detriment of forage. The substitution rate depends on factors such as the amount and type of concentrate supplied, and it is essential to find an adequate balance (POLI et al., 2020).

Regarding starch supplementation, it is important to consider that a higher content of this nutrient may result in a higher replacement rate of forage. On the opposite, supplements with lower starch content and higher amount of digestible fiber tend to promote a lower replacement rate.

The research by Natalello et al. (2019) investigated the effects of feeding whole pomegranate by-product in the diet of lambs on ruminal, hepatic and intramuscular fatty acids. Where the pomegranate by-product partially replaced barley and corn in the dietary concentrate at different levels. It was concluded that the experimental treatment did not affect the body and final carcass weight, dry matter intake and average daily gain.

An ideal supplement should be able to increase pasture intake, while improving its digestibility and passage rate, avoiding being just a substitute. Therefore, it is essential to seek supplementation strategies that optimize forage utilization by sheep, taking into account the relationship between concentrate intake and pasture availability. In this way, it is possible to achieve an adequate nutritional balance and promote the growth and health of animals in a sustainable way.

5 CARCASS CHARACTERISTICS, SHEEP MEAT QUALITY, AND HUMAN HEALTH BENEFITS: DIETARY INFLUENCE

Meat is an essential component of human diets and a source of high-quality nutrients including protein and fat and essential micronutrients (vitamin B, iron and zinc), contributing to physiological metabolism and biochemistry in humans. Current consumers are increasingly aware of these qualities and their health benefits (ABREU et al., 2019; CHIKWANHA et al., 2018).

Factors such as breed, genotype, environment and especially diet offered can influence the muscle and fat composition of meat and, therefore, add to the buyer's acceptance. Consumers are increasingly looking for soft meat, desirable color, rich in quality lipids and low in cholesterol that can reduce the incidence of cardiovascular diseases (ABREU et al., 2019; BRITO et al., 2016). In the past, the objective was to produce meat in quantity at a minimum cost, a fact that contrasts with the current scenario, in which the main interest is in the composition and quality of the final product, based on the understanding that food not only has the function of nourishing but also providing other benefits to the consumer (AUGUSTIN et al., 2015). These characteristics have been modulated by the industry through the diet provided to the animals seeking to meet the demands and expectations of consumers.

Sheep meat products have been growing and gaining popularity mainly for their nutritional properties, traditional quality, physicochemical composition and sensory attributes. Lamb meat stands out for its flavor, and palatability and for being leaner than other meats, being

preferred by the consumer. The consumption of sheep meat is closely associated with some celebrations (TEIXEIRA; SILVA; RODRIGUES, 2019).

The first attribute to gain consumer attention is palatability, a parameter that includes tenderness, flavor, residue and juiciness. This characteristic is dependent on other factors, such as the age of the animal, sex, physiological state of the animal in vivo and the post-mortem procedure of muscle and fat, the composition of the carcass and the contribution of the food used in the diet to the flavor and protein and fat contents (LIMA JÚNIOR et al., 2011; WEBB; CASEY; SIMELA, 2005).

Fat deposition in sheep occurs preferentially, with visceral fat (omental, mesenteric, renal and pericardial) having the earliest development, followed by intermuscular, subcutaneous and intramuscular fat (POPHIWA; WEBB; FRYLINCK, 2020; WEBB; CASEY; SIMELA, 2005). About meat quality, the distribution of fat acts directly on texture, juiciness and flavor and can be classified according to its location as intramuscular, intermuscular and extracellular fat.

Both the physicochemical and sensory characteristics are affected by the type of fat deposited in the tissues, employing a desirable character or not to the consumer. The nutritional quality of ruminants is evaluated based on the composition of fatty acids, by determining indices that relate the content of fatty acids, monounsaturates and polyunsaturated fatty acids n-3 and n-6 series. The reasons between their polyunsaturated fatty acids: monounsaturates and n-3 and n-6 contents are often used in the analysis of the nutritional value of oils and fats and indicate the cholesterolemic potential (SOUSA, 2022).

6 CONCLUSIONS

Animal nutrition plays a fundamental role in obtaining high quality sheep meat with significant benefits for human health. All aspects related to meat quality are of interest to both consumers and the animal protein production chain, which must be aware of market trends and adapt to the specific demands of each segment.

Currently, sheep production focuses mainly on meat production, especially lamb. To enhance meat quality attributes, a variety of additives such as essential oils, propolis, phytochemical extracts and lipid sources are available on the market. These resources can be used to improve shelf life, enhance sensory characteristics and optimize the fatty acid profile of meat, providing direct benefits to human health.

However, further research is needed, especially regarding rumen metabolism, to better understand the benefits of animal nutrition on sheep-derived products intended for consumption. These studies will be essential to deepen our knowledge and further improve sheep meat production, aiming to maximize its health benefits for consumers.

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