DOI: 10.5965/223811712312024159

Revista de Ciências Agroveterinárias 23 (1): 2024
Universidade do Estado de Santa Catarina

Consumption and digestibility of small ruminants fed with babassu oil and mesocarp in the North and Northeast regions of Brazil

Consumo e digestibilidade de pequenos ruminantes alimentados com óleo de babaçu e mesocarpo nas regiões Norte e Nordeste do Brasil

Gleice Kelle Silva Marques Vilela[1] **(ORCID 0000-0003-3505-6285)**, **Steyce Neves Barbosa**[2] (ORCID 0000-0002-1806-4358), **Matheus Bilio Alves**[3] **(ORCID 0009-0007-8311-0107)**, **Diego Carvalho Viana**[3,4] (ORCID 0000-0002-3302-9892), **Thiago Machado da Silva Acioly***[4] (ORCID 0000-0003-2849-5554)

[1]Federal University of Piauí, Teresina, Piauí, Brazil.
[2]Federal University of São Francisco Valley, Petrolina, Pernambuco, Brazil.
[3]Federal University of Tocantina Region of Maranhão, Imperatriz, Maranhão, Brazil.
[4]State University of Maranhão, São Luiz, Maranhão, Brazil. *Author for correspondence: tmsacioly@gmail.com

Submission: 20/05/2023 | *Acceptance: 02/11/2023*

ABSTRACT

Small ruminant husbandry is an important source of subsistence and income for family farmers, contributing to food security and socioeconomic development. To increase the production of these animals while aiming for low feeding costs, it is necessary to resort to different food alternatives that not only reduce expenses but also provide the animals with higher nutrient consumption and utilization. In this context, mesocarp and babassu oil emerge as dietary alternatives, which are generally considered nutritious sources, improving productive performance and reducing metabolic diseases caused by high grain concentration in the diet. The objective of this literature review is to survey the consumption and digestibility of nutrients in small ruminants fed with babassu oil and mesocarp in the North and Northeast regions of Brazil. The selected articles for this review were published in databases from 2013 to 2023, using the following inclusion criteria: babassu oil, babassu mesocarp, alternative feeding, lambs nutrition, intake, and digestibility of nutrients. The studies indicate that babassu oil and mesocarp can be used in small ruminant feeding, resulting in significant gains in nutrient consumption and digestibility. However, there are restrictions regarding the use of these alternative feeds in the diet, with the appropriate quantity for mesocarp being between 10% to 10.5%, and for babassu oil, up to 7%.

KEYWORDS: alternative feed; caprine; ovine; babassu palm; animal production.

RESUMO

A criação de pequenos ruminantes é uma importante fonte de subsistência e renda para os agricultores familiares, contribuindo para a segurança alimentar e o desenvolvimento socioeconômico. Para elevar a produção desses animais visando o baixo custo com a alimentação, se faz necessário recorrer às diferentes alternativas de alimentos, que além de diminuir os gastos, proporciona aos animais maior consumo e aproveitamento dos nutrientes. Nesse sentido, surge então o mesocarpo e o óleo de babaçu, uma alternativa alimentar que se apresenta como fonte nutritiva geralmente melhorando o desempenho produtivo, e reduzindo doenças metabólicas ocasionadas pela alta concentração de grãos na dieta. Objetiva-se com esta revisão de literatura realizar um levantamento sobre consumo e digestibilidade dos nutrientes em pequenos ruminantes alimentados com óleo e mesocarpo de babaçu na região Norte e Nordeste do Brasil. Os artigos escolhidos para esta revisão foram publicados em bases de dados no período de 2013 a 2023, utilizando os seguintes critérios de inclusão: babassu oil, babassu mesocarp, alternative feeding, lambs nutrition, intake and digestibility of nutrients. Os estudos indicam que o óleo e o mesocarpo de babaçu podem ser utilizados na alimentação de pequenos ruminantes, apresentando ganhos significativos quanto ao consumo e digestibilidade de nutrientes. Contudo, há restrição quanto ao uso desse alimento alternativo na dieta, onde, a quantidade adequada para o mesocarpo é entre 10 a 10,5%, e para o óleo de babaçu de até 7%.

PALAVRAS-CHAVE: alimentos alternativos; caprino; ovino; palmeira babaçu; produção animal.

INTRODUCTION

Brazil has a long tradition of raising goats and sheep, which are responsible for the socioeconomic and nutritional support of many rural families, especially those with lower income (SORIO 2017). The national livestock is significant, reaching 20.537.474 million sheep and 11.923.630 million goats as of the last update in September 2021 (IBGE 2023). Sheep are concentrated in the Northeast (54%) and South (32%) regions, while over 90% of goats are concentrated in the Northeast. The state of Maranhão contributes with approximately 299.019 million sheep and 360.155 goats, according to the latest survey (IBGE 2023).

These livestock activities are important sources of subsistence and income for family farmers, contributing to food security and socioeconomic development in these regions. Despite the large livestock population and existing potential, the Northeast region still faces difficulties in recognizing productive indices, mainly due to the lack of information about the herds, the great heterogeneity of producers, and the social, economic, and environmental challenges faced in production. Thus, the participation and commitment of all stakeholders involved in the sector are essential to establish strategies and goals articulated among all links in the production chain (BORGES et al. 2019).

According to NETO (2015), the raising of small ruminants is an activity with great potential for the Northeast region of Brazil, compared to other livestock species, due to the increasing demand for their products in the major Brazilian urban centers, enhanced by the population's increased purchasing power and changes in dietary habits. Additionally, the adaptation of these animals to the region's climatic conditions and their resistance to common diseases are factors that contribute to the success of the activity.

Increasing production while aiming for low feeding costs and a rapid return on investment has been the focus of various studies. For instance, SHILWANT et al. (2023) evaluated plant extracts rich in polyphenols and saponins, which increased nutrient utilization in lactating goats. Meanwhile, HA et al. (2023) assessed grape seed extract in goats' diets and observed an increase in the consumption of ether extract (EE) by these animals. Additionally, babassu mesocarp and oil are alternative feed sources that provide nutrition with the potential to improve animal performance and reduce metabolic diseases caused by a high grain concentration in the diet (MENEZES et al. 2022).

According to SOUZA (2019), including babassu mesocarp in animal feed is an excellent energy alternative, especially due to its composition with starch content of up to 75%. On the other hand, babassu oil is mainly employed for its significant attributes, such as providing essential fatty acids and fat-soluble vitamins to the animals, in addition to its high energy content, containing approximately twice as many calories per gram of carbohydrates, as mentioned by DIÓGENES et al. (2020). This information underscores the relevance of these natural resources as nutritional and energy options in animal feeding, particularly for small ruminants.

The main objective of this review study is to investigate the consumption and digestibility of nutrients in small ruminants fed with babassu oil and mesocarp. This research is of great importance to rural producers, especially in the North and Northeast regions, and in the states of Maranhão, Piauí, and Tocantins, where the babassu palm is predominant. Furthermore, it can stimulate new research and investigations in this area, encouraging the search for innovative solutions to improve the nutrition and production of small ruminants.

MATERIALS AND METHODS

This research followed a bibliographic study design, where searches were conducted in books, dissertations, theses, and scientific articles from the following databases: Scopus, Web of Science, Short Communication, SciELO, and Google Scholar. The content presented had an exploratory nature, aiming to provide technical and scientific support for the use of babassu oil and mesocarp in the feeding of small ruminants in the North and Northeast regions of Brazil.

Articles selected for inclusion in this study were published in databases from 2013 to 2023. The inclusion criteria were based on the following Portuguese and English descriptors and their combinations: babassu oil, babassu mesocarp, alternative feeding, lambs' nutrition, intake, and digestibility of nutrients. As exclusion criteria, bibliographic documents unrelated to the research theme and publications outside the specified period and region were not selected.

It is important to note that as a bibliographic study, this research did not involve direct experiments or data collection from animals. Instead, it focused on reviewing and analyzing existing literature to provide scientific insights into the potential benefits of using babassu oil and mesocarp as feed alternatives for small ruminants in the specific region. It should be noted that few studies have been carried out to evaluate the

nutritional value of this product in the North and Northeast regions.

DEVELOPMENT

This section is divided into three subsections, namely: 1) The Babassu palm (Attalea speciosa Mart. ex Spreng) and its role in the sustainable development; 2) Babassu oil and mesocarp in the alternative feeding of small ruminants; 3) Consumption and digestibility of nutrients in small ruminants fed with babassu mesocarp and oil.

The Babassu palm (*Attalea speciosa* Mart. *ex Spreng*) and its role in the sustainable development

The *Attalea speciosa* Mart. *ex. Spreng*, also known as babassu, is a native palm tree of Brazil found mainly in the Amazon and Cerrado regions (SANTOS et al. 2022a). However, it can also be found in humid tropical countries of South America, such as Suriname, Bolivia, and Guyana (SOUSA et al. 2023). It is a species of significant economic and ecological importance, as it provides various resources for local communities and plays a vital role in the ecosystem of these regions.

The babassu palm can reach a height of 20 meters, producing four fruit clusters per tree per season. The trees start producing between seven and ten years old and continue until 35 years old, with a productivity range of 2.2 to 15.6 tons of fruit per hectare per year (SILVA et al. 2019). It is worth noting that the national production is approximately 32.076 thousand tons of babassu (IBGE 2021), with the state of Maranhão being the main producer of babassu kernels in the country, with a total of 44 thousand tons per year (CORRÊA 2022).

The babassu fruit has an average weight of 90 to 280g (COSTA et al. 2020) and is divided into four parts (Figure 1), namely: kernel (79%), endocarp (59%), mesocarp (23%), and exocarp (11%) (NASCIMENTO et al. 2019). The kernels are used in human and animal nutrition, cosmetics, cleaning products, and medicines; the endocarp is used for fuel production; the mesocarp is utilized for producing flour for human and animal consumption, charcoal, and medicines; and the exocarp is used in making baskets, producing fertilizers, and charcoal (CORDEIRO et al. 2022).

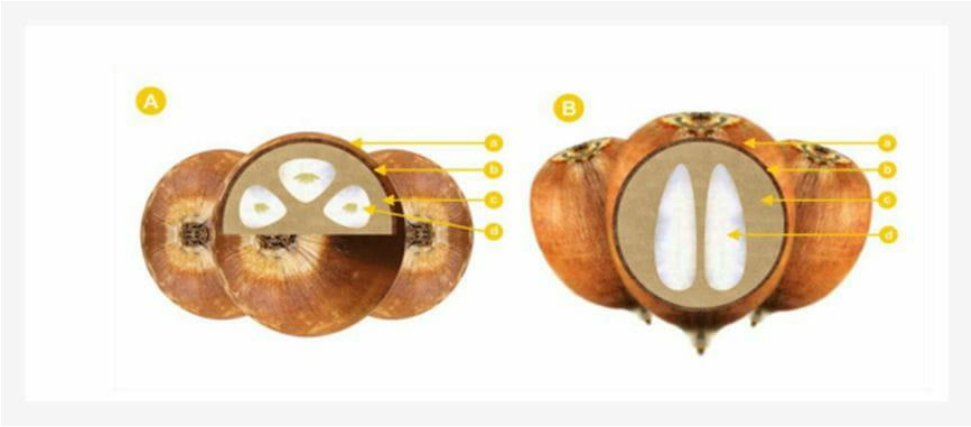

Figure 1. Schematic cut of the Babassu coconut. (A): Cross-section. (B): Longitudinal section. a: Exocarp; b: Mesocarp; c: Endocarp; e: Kernel. Source: BARROS (2011).

In developed countries such as the United States and China, babassu is used for commercial purposes by foreign multinational companies, focusing on the specific market of beauty cosmetics (CORDEIRO et al. 2022). This is a matter of national concern since babassu is considered a natural genetic resource and part of Brazil's genetic heritage. TENÓRIO et al. (2019) highlight the low concentration of efforts and biodiversity protection technologies, emphasizing the need to establish policies that encourage research and the development of national technologies.

In Brazil, babassu kernels are one of the main products of plant extraction. Secondary babassu forests are found in the transition between the Amazon, Cerrado, and the northeastern semi-arid region, where one of the most significant peasant populations in the country resides. Projections for Maranhão indicate a monetary valuation of the entire production of babassu derivatives at approximately R$ 100 million (PORRO 2019). For example, for coconut breakers and other traditional communities in Maranhão, the babassu palm is of extreme socioeconomic importance (BARROSO et al. 2019), providing income and livelihood for rural

communities in the state, especially in the region of Imperatriz. Products derived from babassus, such as its fruits or coconuts, leaves, and extracts, have been used for many generations as part of traditional medicine to treat stomach problems, skin wounds, various inflammations, and menstrual cramps (MAGALHÃES et al. 2019). Babassu coconut is a residue in extractive production with greater economic value for local communities, mainly due to its commercial value in the production of babassu vegetable oil, medicines, and cosmetics (PAIXÃO et al. 2019). Furthermore, it has favorable chemical properties for biodiesel production in Brazil (ANJOS et al. 2021), as well as for human and animal consumption.

It is worth noting that, in addition to the various uses of babassu coconut, the leaves are also used by the Kayapó indigenous people to make masks representing animals, such as monkeys, in various traditional festivals (MITJA et al. 2019). Therefore, the babassu palm has significant socioeconomic and cultural importance, often exploited for its various benefits to society. Additionally, its long-term presence in primary forests and pastures provides an important resource for wildlife through its fruits (SANTOS et al. 2022a). According to FAKHOURI et al. (2021), the importance of babassu lies in the 70 products that can be extracted from its palm, fruits, and coconut, with special emphasis on the production of babassu flour and oil for human and animal consumption (GERUDE NETO et al. 2016).

In the Northeast, babassu by-products and co-products have also emerged as an alternative source with high nutritional value for animal feed, such as endocarp flour, resulting from an industrial process obtained from the cross-sectional cutting of the fruit, separated from the endocarp and almonds, and crushed in a sequential system of sieves and filters. Like mesocarp flour, endocarp flour has high digestibility and utilization by small ruminants. A study conducted in the state of Tocantins by SÁ et al. (2014) concluded that the inclusion of endocarp flour in diets for sheep should be around 15% and that increasing inclusions of endocarp flour reduces feeding and rumination efficiency.

Consequently, babassu bran is an effective by-product that, in addition to contributing to better performance and greater weight gain in small ruminants, does not interfere with the carcass characteristics of sheep when included in diets at levels of up to 20%, as confirmed by (JÚNIOR 2003), who tested the inclusion of babassu bran in the diet of sheep in a study conducted in Teresina, Piauí. Similar results were found by (NETA et al. 2021) in a study conducted in the state of Amazonas, where they evaluated four levels of babassu cake (0; 26; 66; 53.33, and 80%) as a substitute for soybean meal. There was no effect ($P > 0.05$) of replacing soybean meal with babassu cake on nutrient consumption (DM, NDF, and CP).

Babassu oil and mesocarp as alternative feed for small ruminants

Babassu oil is derived from the process of extraction, grinding, heating, and pressing of the kernels (PAIXÃO et al. 2019); it comes from the babassu palm and stands out for its antioxidant characteristics (BAUER et al. 2019). It is composed of approximately 86.42 to 91% saturated fatty acids (SERRA et al. 2019), of which 47.40% is lauric acid ($C_{12}H_{24}O_2$), 15.64% is myristic acid ($C_{14}H_{28}O_2$), and 11.28% is oleic acid ($C_{18}H_{34}O_2$) (MELO et al. 2019). Its use in the diet of small ruminants is mainly due to its physicochemical characteristics (DIÓGENES et al. 2020) and its ability to serve as an available source of energy (PARENTE et al. 2020).

Based on this information, it can be concluded that babassu oil presents significant benefits in the feeding of sheep. The study by PAIXÃO et al. (2019) demonstrated that the inclusion of babassu oil in the diet resulted in positive gains in the quality and production of fatty acids in the meat of the animals. Furthermore, it can improve animal performance and reduce possible metabolic diseases caused by the high concentration of grains in the diet of intensive production (MENEZES et al. 2022). It is worth noting that, in addition to the nutritional benefits, the use of babassu oil also offers a sustainable alternative to the disposal of this byproduct, which was previously considered waste, thus becoming an option that contributes to mitigating impacts on natural resources (ZANINE et al. 2023).

Supplementing ruminant animals with babassu oil can increase stress on ruminal bacteria, affect biohydrogenation in the rumen, and alter the concentration of fatty acids in the abomasum. This effect is possible because the oil is rich in medium-chain fatty acids, primarily lauric acid ($C_{12}H_{24}O_2$), as mentioned by PARENTE et al. (2020). Additionally, it is less susceptible to oxidative degradation compared to other vegetable oils that have high concentrations of polyunsaturated fatty acids, as reported by MACHADO et al. (2022).

Another alternative feed that has proven to be efficient in the feeding of small ruminants is babassu mesocarp, one of the most abundant parts of the babassu coconut, accounting for 23% of the total mass

(PAIXÃO et al. 2019). It is derived from the extraction of kernels, which are often discarded, but it presents a high potential for animal feed supplementation (ZANINE et al. 2023).

Furthermore, mesocarp flour is a product resulting from the removal of the epicarp and separation of the mesocarp before the fruit is sawn for kernel extraction, and due to its high starch content, it can be an alternative source of energy for animal feed, contributing to the reduction of costs of diets for small ruminants (SANTOS et al. 2020). Often, this product is used without scientific support by local livestock farmers for ruminant feeding due to its high availability and nutritional potential (Table 1), compared to other regionally available byproducts (PORRO 2019).

Table 1. Chemical composition of the oil and mesocarp babaçu.

Chemical composition (% of DM)	*MACHADO et al. (2022)*	*PARENTE et. al. (2020)*	*VILELA (2023)*	*GERUDE NETO et al. (2016)*	*SANTOS et al. (2018)*
	Diets				
	Babassu Oil			Babassu Mesocarp	
Dry matter	90.9	91.1	89.8	89.9	90.3
Organic matter	94.95	95.0	-	92.7	97.0
Crude protein	16.55	16.6	17.4	4.0	16.3
Neutral detergent fiber	39.63	39.6	39.8	-	37.8
Non-fiber carbohydrates	32.41	32.4	30.8	35.1	40.9
Metabolizable energy (MJ/kg)	2.91	1.22	3.16	-	2.8
Ether extract	-	5.9	6.9	0.9	1.6

Source: MACHADO et al. (2022), PARENTE et. al. (2020), VILELA (2023), GERUDE NETO et al. (2016), SANTOS et al. (2018).

The mesocarp has about 75.1% starch in its nutritional composition (SOUZA 2019). Despite its high starch content, there may be contamination in the mesocarp extraction process by epicarp and endocarp, which are fibrous byproducts, resulting in babassu mesocarp flour with high fiber content and lower starch content (GERUDE NETO et al. 2016). In this scenario, it is important to note that foods with high fiber content can affect animal behavior and cause digestive disorders, consequently reducing production (ARAÚJO et al. 2020).

Given this, authors like SANTOS et al. (2020) and CRUZ et al. (2015) conducted studies with other ruminant species, such as goats and cattle, to validate the nutritive potential of babassu mesocarp. In sheep, the inclusion of babassu mesocarp flour in the diet can increase voluntary intake and negatively influence rumination (ARAÚJO et al. 2020). The producer must be cautious to avoid losses in animal appetite and nutrient digestibility (SOUSA et al. 2021).

A study conducted in Teresina, in the state of Piauí, aimed to evaluate the influence of alternative diets with babassu meal for finishing sheep (SOUSA JR et al. 2007). The authors assessed the *in vivo* digestibility of dry matter, crude protein, and energy of different diets and observed that there was no effect ($P<0.05$) of including babassu meal up to 30% of the diet on dry matter digestibility (65.16±7.18%). Meanwhile, CASTRO et al. (2020), in a study conducted in Araguaína, Tocantins state, evaluated the nutritional value of diets containing babassu cake replacing Tifton-85 hay (70; 140; 210; 280 and 350 g kg^{-1} of dry matter; DM). Dry matter intake was not influenced; however, crude protein (CP) and ether extract intake increased linearly. The inclusion of babassu cake did not affect DM digestibility (mean of 604.6 ± 272.8 g kg^{-1}). The apparent digestibility of CP and total digestible nutrients showed a linear increasing trend, and acid detergent fiber (ADF) digestibility decreased linearly.

Consumption and nutrient digestibility in small ruminants fed with babassu oil and mesocarp

Digestibility is directly related to the nutrients present in the diet; thus, it serves as a measure to identify how much of the diet is digestible or how much of these nutrients are utilized by the animal. Therefore, consumption and digestibility are necessary to determine the nutritional value of the foods

provided to the animals (BERCHIELLI et al. 2005). According to MALAGUEZ et al. (2021), it is essential to seek alternative ingredients with high nutritional potential and lower acquisition costs, as corn and other commodities have highly variable prices.

Therefore, the use of agro-industrial by-products in the feeding of small ruminants presents nutritional, environmental, and economic advantages, directly contributing to the sustainability of Brazilian agriculture (CASTRO et al. 2020). For this reason, studies are being refined for the utilization of these by-products in animal production as part of the diet for sheep and goats, aiming to reduce feeding costs and improve nutrient digestibility, with a positive impact on consumption, consequently enhancing the productive performance of these animals (Table 2).

Table 02. Intake (g/d $^{-1}$) and nutrient digestibility (g/kg $^{-1}$) of small ruminants fed with oil and babassu mesocarp included in the literature.

Item	GERUDE NETO et al. (2016)	SANTOS et al. (2018)	SANTOS et al. (2019)	PARENTE et al. (2020)	MACHADO et al. (2020)	GOMES (2018)	MACHADO et al. (2022)	VILELA (2023)
	Diets							
	Babassu Mesocarp				Babassu Oil			
	Dry matter							
Intake	1397.6	1172.6	821.34	570	907.7	771.94	804	501.45
Digestibility	76.5	-	-	-	-	78.06	75.3	82.04
	Crude protein							
Intake	239.2	233.1	-	105	-	140.94	154	99.39
Digestibility	91.4	-	-	-	-	76.66	77.7	86.30
	Organic matter							
Intake	1273.0	1182.3	-	507	-	732.99	-	474.02
Digestibility	77.9	-	-	-	-	79.46	-	83.09
	Neutral detergent fiber							
Intake	490.2	425.3	437.86	195	300.6	272.80	280	201.95
Digestibility	60.2	-	-	-	-	64.78	59.8	76.13
	Ether extract							
Intake	17.4	19.6	-	39.4	-	52.82	-	31.27
Digestibility	83.7	-	-	-	-	80.92	-	85.17
	Total carbohydrates							
Intake	1094.0	1000.2	-	363	-	531.57	563	341.13
Digestibility	76.5	-	-	-	-	79.65	75.9	79.48
	Nonfiber carbohydrates							
Intake	603.8	580.9	-	190	-	258.72	284	182.12
Digestibility	89.7	-	-	-	-	95.23	92.4	88.35
	Metabolizable energy (MJ/d)							
Intake	-	-		7.17	-	2.27	2.37	1.24

Source: GERUDE NETO et al. (2016), SANTOS et al. (2018), PARENTE et. al. (2020), MACHADO et al (2020), GOMES (2018), MACHADO et al. (2022), VILELA (2023).

Dietary fat is an important component of animal nutrition; therefore, it is essential to consider the quality and adequate quantity in the animal's diet to ensure their well-being and productivity. Babassu oil in the diet of lambs does not alter energy intake and the performance of these animals (PARENTE et al. 2020). On the other hand, MACHADO et al. (2022) observed that the inclusion of babassu oil in the diet of lambs increases the consumption and digestibility of fatty acids. A similar result was found in the experiment by ANJOS et al. (2018), who, when working with finishing sheep, noticed an increase in the total digestibility of fatty acids with the addition of babassu oil to the diet. However, it is important to note that the inclusion of oils in rations should be up to 7% ether extract (EE) on a dry matter basis; higher values may limit the intake and digestibility of other nutrients and inhibit the action of ruminal microorganisms, compromising production (PAULA et al. 2020).

On the other hand, the mesocarp stands out for its efficiency in animal nutrition, especially due to its bromatological composition, which has aroused economic interest. It contains 87.5% dry matter, 3.29% crude protein, 0.64% ether extract, and 75.1% starch, being considered an energy food (SOUZA 2019). Additionally, it presents 20% fiber, 8 to 15% moisture, and 4 to 5% other substances, such as minerals (SILVA et al. 2021). Furthermore, it is noted that its use does not influence NDF (Neutral Detergent Fiber) but increases the digestibility of ether extract (EE), the consumption of non-fibrous carbohydrates, and TDN (Total Digestible Nutrients) (SANTOS et al. 2018, GERUDE NETO et al. 2016).

The inclusion of babassu mesocarp flour up to 10% on a dry matter basis in the diet of sheep proves to be advantageous as it increases the digestibility of ether extract (EE) and can be indicated as an alternative source of energy in lamb feeding (GERUDE NETO et al. 2016). SANTOS et al. (2022b) also observed that the addition of babassu mesocarp flour in sheep diets can be used at concentrations of up to 10.5%, providing an effective increase in dry matter intake. In this context, a study conducted in Maranhão by SÁ et al. (2023) reported higher levels of ether extract in corn silage (control group) compared to silage made with 50% babassu mesocarp meal and 50% soybean meal. The animals maintained an appropriate fermentative profile. These studies contribute to the understanding of the nutritional benefits and potentialities of this by-product in the feeding of small ruminants.

A study conducted in the state of Tocantins by MIOTTO et al. (2012) assessed the inclusion of babassu mesocarp meal as a replacement for elephant grass at different ratios on the intake and apparent nutrient digestibility in sheep. They observed that the diets did not influence the intake of DM, organic matter (OM), CP, NDF, ADF, and hemicellulose (DAHEM), with coefficients of variation (CV) of 38.7, 38.7, 38.5, 34.7, 36.0, and 32.6, respectively. However, the digestibilities of DM, NDF, ADF, CP, and non-fibrous carbohydrates (NFC) decreased as the proportion of babassu mesocarp meal (FMB) in the diets increased, and the apparent digestibilities of dry matter (DAMS), ether extract (EE), and NFC exhibited a quadratic response, with a maximum estimated DADS at 10% FMB. Therefore, despite the reduction in the digestibility of some nutrients, the use of babassu mesocarp meal as a replacement for elephant grass is satisfactory.

Animal feeding is one of the primary components of an agricultural production system, directly affecting carcass quality. In the North and Northeast regions of Brazil, feeding remains a limiting factor for sheep weight gain, primarily due to the low availability and high cost of conventional concentrated feeds (XENOFONTE et al. 2009). As long as sheep production in these regions relies on grains such as soy and corn, caprine and ovine farming may not always be economically viable due to seasonal price fluctuations and rising diet costs (DANTAS 2018). Therefore, the use of alternative feeds is appropriate.

In a study conducted by DANTAS (2018) in Macaíba, located in the state of Rio Grande do Norte within the Northeast region of Brazil, the consumption, performance, and carcass yield of sheep fed with different protein sources, such as soybean meal, cottonseed cake, coconut cake, and babassu cake, were evaluated. The results demonstrated that babassu cake provided satisfactory performance in terms of dry matter intake (DMI), average daily gain (ADG), and total weight gain, reaching values of 1.11 kg/day, 162.84 g/day, and 12.35 kg, respectively. According to the experiment conducted in the North region (state of Pará) by LUZ et al. (2019), the inclusion of babassu cake as a replacement for grass demonstrated appropriate levels of DMI, NDF, and TDN. These findings indicate that babassu cake can be a viable alternative to soybean meal in confinement sheep diets, in addition to being a more economical option.

CONCLUSION

Babassu oil and mesocarp can be used in the feeding of small ruminants, presenting significant gains in nutrient intake and digestibility. However, there are restrictions regarding the use of these alternative feed ingredients in the diet, where the appropriate quantity for mesocarp is between 10 to 10.5%, and for babassu oil up to 7%. Exceeding these appropriate levels could negatively impact dry matter intake and other nutrient consumption. These alternatives are effective for increasing production at low cost and represent economically viable sources of feed, especially for small family farmers in the state of Maranhão and the North/ Northeast region of Brazil.

REFERENCES

ANJOS LF et al. 2018. Digestibilidade de ácidos graxos em ovinos em terminação alimentados com dietas contendo óleos de babaçu ou buriti. Goiânia.28º Congresso Brasileiro de Zootecnia.

ANJOS SSN et al. 2021. Avaliação do impacto de política de subvenção econômica na cadeia produtiva de biodiesel de

babaçu. Revista em Agronegócio e Meio Ambiente 14: 1-16.
ARAÚJO CM et al. 2020. Consumption and ingestive behaviour of lambs fed varying levels of babassu mesocarp bran. Ciências Agrárias 41: 1-13.
BARROSO OB et al. 2019. Babassu coconut breakers from the state of maranhão: fight and resistance repertory. Revista debates insubmissos 4: 1-19.
BARROS IC. 2011. Avaliação Biofarmacotécnica de potencial excipiente farmacêutico: pó de mesocarpo de babaçu (*Orbignya phalerata* Mart.). Dissertação (mestrado). Teresina: UFPI.21-28p.
BAUER LC et al. 2019. Antioxidant activity and bioactive compounds of 44 babassu (Orbignya phalerata) virgin oil obtained by different methods of extraction. The Open Food Science Journal 11: 35-43.
BERCHIELLI TT et al. 2005. Application of techniques for intake, diet composition and digestibility studies. Archives of Veterinary Science 10: 29-40.
BORGES LS et al. 2019. Gestão zootécnica e genética informatizadas em pequenos ruminantes: uma revisão. Medicina Veterinária 13: 251–257.
CASTRO KJ et al. 2020. Nutritional value of babassu cake as a replacement for roughage in sheep feed. Revista Ciência Agronômica 51: 1-9.
CORDEIRO LS et al. 2022. Cenário das patentes relacionadas ao babaçu no contexto do conhecimento tradicional associado ao fruto. Informação & Informação 27: 180-206.
CORRÊA BA. 2022. Mudanças no uso e ocupação do solo e suas implicações para a cadeia produtiva do babaçu (*Attalea speciosa*) na região dos cocais, estado do Maranhão, Brasil. Dissertação. (Mestrado em Ciências Florestais). Macaíba: UFRN. 55p.
COSTA A et al. 2020. Physicochemical and nutritional aspects of babassu coconut almond and oil (Orbignya phalerata mart.). Revista Chilena de Nutrición 47: 57-66.
CRUZ RS et al. 2015. Características das carcaças e carne de tourinhos Nelore alimentados com níveis de concentrado e farelo do mesocarpo de babaçu. Arquivo Brasileiro de Medicina Veterinária e Zootecnia 67: 299-308.
DANTAS JLS. 2018. Fontes proteicas alternativas na alimentação de ovinos em confinamento. Dissertação (Mestrado em Produção Animal). Macaíba: UFRN. 43p.
DIÓGENES L et al. 2020. Effects of the dietary inclusion of buriti oil on lamb performance, carcass traits, digestibility, nitrogen balance, ingestive behavior and blood metabolites. Animals 10: 1-13.
FAKHOURI FM et al. 2021. *Attalea speciosa (Orbignya phalerata*). In: FREITAS DE LIMA F et al. (eds). Fruits of the Brazilian Cerrado: Composition and Functional Benefits. p.125-139.
GERUDE NETO OJAG et al. 2016. Intake, nutrient apparent digestibility, and ruminal constituents of crossbred Dorper× Santa Inês sheep fed diets with babassu mesocarp flour. The Scientific World Journal 41: 2350-2356.
GOMES RMS. 2018. Óleo de buriti e babaçu na dieta de ovinos confinados. 35f. Dissertação (Mestrado em Ciência Animal). Chapadinha: UFMA. 35 p.
HA TTN et al. 2023. Effects of oil and grape seed tannin extract on intakes, digestibility, milk yield and composition of Saanen goats. Veterinary Integrative Sciences 21: 37-47.
IBGE. 2021. Pesquisa da Pecuária Municipal. Tabela 74: Produção de origem animal, por tipo de produto. Rio de Janeiro, 2021. Disponível em: <https://www.ibge.gov.br/explica/producao- agropecuaria/ovino/br>. Acesso em: 29 abr. 2023.
IBGE. 2023. Rebanho de Caprinos e Ovinos. Disponível em: < https://www.ibge.gov.br/explica/producao-agropecuaria/caprinos/br>. Acesso em: 02 ago 2023.
JÚNIOR VCR. 2003. Determinação do valor energético de alimentos para ruminantes pelo sistema de equações. Revista Brasileira de Zootecnia 32: 473-479.
LUZ JB et al. 2019. Performance and digestibility of confined lambs fed with Babassu cake (Orbignya speciosa) as a substitute for elephant grass silage. Arquivo Brasileiro de Medicina Veterinária e Zootecnia 71: 977-982.
MACHADO N et al. 2022. Effects of dietary babassu oil or buriti oil on nutrient intake and total tract digestibility, and abomasal digesta fatty acid profile of lambs. Animals 12: 1-13.
MACHADO NAF et al. 2020. The physiological response, feeding behaviour and water intake of feedlot lambs supplemented with babassu oil or buriti oil. Biological Rhythm Research 51: 213-224.
MAGALHÃES KN et al. 2019. Medicinal plants of the Caatinga, northeastern Brazil: Ethnopharmacopeia (1980–1990) of the late professor Francisco Jose de Abreu Matos. Journal of Ethnopharmacology 237: 314–353.
MALAGUEZ EG. et al. 2021. Effect of different levels of Ipomoea batatas flour inclusion on the ruminal pH of sheep in metabolic cages. Acta Scientiarum. Animal Sciences 43: 1-6.
MELO E et al. 2019. First study on the oxidative stability and elemental analysis of babassu (Attalea speciosa) edible oil produced in Brazil using a domestic extraction machine. Moléculas 24: 4235 – 4241.
MENEZES GL et al. 2022. Efeito do uso de óleos essenciais no desempenho de bovinos de corte confinados. PUBVET 16: 1-7.
MIOTTO FRC et al. 2012. Consumo e digestibilidade de dietas contendo níveis de farelo do mesocarpo de babaçu para ovinos. Revista Ciência Agronômica 43: 792-801.

MITJA D et al. 2019. Viability of the babassu palm eco-socio-system in Brazil: the challenges of a coviability. Coviability of Social and Ecological Systems: Reconnecting Mankind to the Biosphère in an Era of Global Change, Vol. 2: Coviability Questioned by a Diversity of Situations 2: 257-284.

NASCIMENTO JM et al. 2019. Chemical characterization of biomass flour of the babassu coconut mesocarp (Orbignya speciosa) during the biosorption process of copper ions, Environmental Technology & Innovation 16: 4-12.

NETA S et al. 2021. Utilização da torta de babaçu e da silagem de resíduo de abacaxi em dietas para ovinos confinados. Semina: Ciências Agrárias 42: 795-808.

NETO JMS. 2015. Caracterização dos sistemas de produção da ovinocaprinocultura no Nordeste brasileiro. Tese. (Doutorado em Zootecnia). Fortaleza: UFC. 93p.

PAIXÃO LC et al. 2019. Aplicações farmacêuticas e bioprodutos do babaçu (Attalea speciosa Mart.ex x Spreng): revisão. Pharmaceutical applications and bioproducts of babassu (Attalea speciosa Mart. ex Spreng): review. Ciências da Saúde 21: 1-10.

PARENTE MOM et al. 2020. Effects of the dietary inclusion of babassu oil or buriti oil on lamb performance, meat quality and fatty acid composition. Meat Science 160: 2-14.

PAULA PRP et al. 2020. Composição bromatológica da silagem de capim- elefante BRS Capiaçu com inclusão do fubá de milho. PUBVET 14: 1-8.

PORRO R. 2019. A economia invisível do babaçu e sua importância para meios de vida em comunidades agroextrativistas. Boletim do Museu Paraense Emílio Goeldi. Ciências Humanas 14: 169-188.

SÁ C et al. 2023. Corn silage as a total diet with by-products of the babassu agroindustry in the feed of confined ruminants. Agronomy 13: 1-10.

SANTOS AMS et al. 2022a. What is the influence of anthropogenic impact on the population structure of *Attalea speciosa* Mart. ex Spreng. In the Brazilian Amazonian region. Acta Botanica Brasilica 36: 1-13.

SANTOS ARD et al. 2022b. The physiological response, feeding behaviour and water intake of goat kids fed diets with increasing levels of babassu mesocarp flour. Biological Rhythm Research 53: 369-381.

SANTOS PAC et al. 2018. Farinha de mesocarpo Babassu na dieta de cordeiros de acabamento. Italian Journal of Animal Science 18: 236–245.

SANTOS ARD et al. 2019. The physiological response, feeding behaviour and water intake 416 of goat kids fed diets with increasing levels of babassu mesocarp flour. Biological Rhythm 417 Research. 10.1080.

SANTOS PAC et al. 2020. Economic analysis of babassu flour starch addition in the diet of feedlot lambs. Brazilian Journal of Animal and Environmental Research 3: 1421-1426.

SERRA JL et al. 2019. Alternative sources of oils and fats from Amazonian plants: Fatty acids, methyl tocols, total carotenoids and chemical composition. Food Research International 116: 12-19.

SHILWANT S et al. 2023. Ruminal fermentation and methane production in vitro, milk production, nutrient utilization, blood profile, and immune responses of lactating goats fed polyphenolic and saponin-rich plant extracts. Environmental Science and Pollution Research 30: 10901-10913.

SILVA FGS et al. 2021. Propriedades funcionais da farinha do mesocarpo do coco babaçu: uma alternativa nutricional contra a Covid-19. Society and Development 10: 1-9.

SILVA NC et al. 2019. Effect of babassu (Orbignya phalerata) mesocarp flour on the sensorial properties and nutritional value of cookies. Journal of Food and Nutrition Research 11: 805-809.

SORIO A. 2017. Diagnóstico da oferta e demanda de ovinos e caprinos para processamento de carne, pele e leite na região central do Tocantins. Tocantins: 19: 9-199.

SOUSA JR A et al. 2007. Digestibilidade de dietas contendo farelo de babaçu para ovinos em terminação. Archivos de zootecnia 56: 967-970.

SOUSA LF et al. 2021. Babassu mesocarp meal for ewe lambs feeding: In vitro ruminal fermentation and in vivo apparent digestibility. Acta Scientiarum 43: 1-7.

SOUSA HR et al. 2023. Innovative hydrogels made from babassu mesocarp for technological application in agriculture. Journal of Molecular Liquids 376: 121463.

SOUZA MIA. 2019. Influência da inclusão de glicerina em substituição ao farelo de mesocarpo de babaçu e milheto na qualidade da carne bovina. Tese. (Doutorado em Ciência Animal) Goiânia. UFG. 94p.

TENÓRIO LXS et al. 2019. Potenciais tecnologias e patenteabilidade de tecnologias derivadas de extratos vegetais. Cadernos de Prospecção 12: 136-152.

VILELA GKSM. 2023. Parâmetros nutricionais de ovinos Alimentados com dietas contendo associação dos óleos babaçu e girassol. Dissertação. (Mestrado em Ciência Animal). Maranhão. UFMA. 432p.

XENOFONTE ARB et al. 2009. Características de carcaça de ovinos em crescimento alimentados com rações contendo farelo de babaçu. Revista Brasileira de Zootecnia 38: 392-398.

ZANINE A et al. 2023. The effect of babassu industry by-products as an alternative feed for dairy cows. Agronomy 13: 491.