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MINI REVIEW

Improving rabbit performance, meat quality and composition through forages

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Abstract

A literature review was carried out in the main international databases (Redalyc, SciELO, Scopus, Elsevier, EBSCO, and Scholar Google) using rabbit meat, rabbit meat composition and chemical composition of rabbit meat, forages in rabbit feeding as the main keywords, in the period from 2000 to 2023, to identify tropical resources that have been studied for rabbit meat production, as well as the effects on carcass characteristics and meat quality. Twenty-five species of tropical resources that have been studied for rabbit meat production were identified. The reported studies were related to productive performance, carcass characteristics, and meat quality. The use of forages in rabbit feeding has been highlighted by improving nutrient consumption and productive behavior in growing and fattening animals. Concerning the effects on carcass characteristics, improvements are reported in organoleptic aspects, as well as increases in carcass performance, percentage of carcass muscle, and muscle-bone ratio. Regarding meat composition, increases in protein content per 100 g of muscle, a decrease in fat content in the carcass, and an increase in the content of essential fatty acids and selenium are reported. In conclusion, the use of forages in rabbit meat production is viable and improves the quality of the carcass and meat.

1. Introduction

Rabbit meat has been promoted worldwide to combat malnutrition and diseases related to unhealthy eating habits in different age groups of humans; It has been classified as white meat due to its nutritional characteristics, among which are high protein content (20 – 21%) and low-fat content (Dalle-Zotte, 2002). Additionally, rabbit meat has high concentrations of fatty acids (oleic and linoleic) as well as minerals (potassium, phosphorus, and magnesium) (Dalle-Zotte, 2002; Iyeghe -Erakpotobor, 2007; Teye *et al.,* 2020). In this sense, rabbit meat can be considered useful to reduce the risk of suffering from pathologies such as diabetes, specific hypertension through its chemical composition (very low levels of monounsaturated fatty acids, high levels of polyunsaturated fatty acids, high content of vitamin B2, B3, B5, B6, and B12); very low levels of sodium and phosphorus; However, despite these characteristics, it has been shown that it can still be improved through feed and elements in the diet such as extracts of plants (nutraceuticals), vitamin E, prebiotics can modify the quality of meat (Dalle Zotte and Szenderö, 2011; Ezeonu and Akobueze, 2012; Rotolo *et al.,* 2013; Cardinali *et al.,* 2015; Mattioli *et al.,* 2017). However, information regarding fortification or modifications of nutritional characteristics in rabbit meat is still scarce (Mattioli *et al.,* 2017).

The rabbit is a monogastric herbivorous animal; the particularities of its gastrointestinal system and its digestive physiology make its breeding and production feasible with forage resources with high concentrations of fiber which is not advisable in other monogastric species and without competing with human food (Nieves *et al.,* 2009; Akoutey *et al.,* 2012). In previous years, European countries studied the use of fibrous sources in rabbit feeding, which favored their study in different tropical areas of the world, demonstrating that the wide diversity of tropical resources and their biomass productive potential allows an increase in economic profit of 2.43% and nutritional quality of rabbit meat (Nieves *et al.,* 2009; Sánchez-Laiño *et al.,* 2018). In the

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present work, various forage resources are presented, which have been studied for rabbit feeding and their effects on productive behaviour, carcass characteristics, and meat quality.

2. Forages studied for rabbit meat production

2.1 Forages studied for rabbit meat production

According to Lebas (2013), in rabbit production, as in any other animal production, feeding strategy should be based on traits such as feeding behavior and nutritional requirements of the animal, as well as the type and sources of feed available for the production unit. Tropical areas worldwide exhibit wide potential for feeding herbivores like rabbits. Between 2000 and 2023, a total of 25 resources from tropical areas were identified and used experimentally to feed rabbits; These resources were studied in different utilization schemes such as ad libitum, inclusion levels, or supplements (Table 1).

2.2 Nutraceutical effects of using forages on rabbit production performance, meat quality and composition

The use of tropical forages in rabbit feeding can effectively modify different productive and meat quality traits, such as the content of essential fatty acids, omega 3 polyunsaturated, conjugated linoleic acid, eicosapentaenoic acid, docosahexaenoic acid (DHA), chain fatty acids branched, selenium or vitamin E, as well as carcass characteristics (Dalle Zotte and Szendro, 2011; Kaga, 2013; Assan, 2018; Escribá-Pérez *et al.,* 2019).

Plants as nutraceutical alternatives and feed additives in rabbit diets, separately or in combination, to act as natural growth promoters, antioxidants, anti-inflammatories, antimicrobial agents, and immunostimulants in rabbit farms. Nutraceuticals are natural chemical substances that have a good impact on animal growth performance and mg/kg of diet, respectively. Supplementation improved physiological and productive characteristics (Veneziani *et al.,* 2017). The study of available and alternative feed additives that enhance the nutritional characteristics of meat is important for the rabbit industry, particularly in subtropical and Mediterranean-developing countries. The meat processing industry is driven by increasing consumer demand for healthier meat products with specific characteristics such as reduced levels of fat, cholesterol, sodium, and nitrite and improved composition of fatty acids, comprising omega-3 fatty acids, enriched meat products. Healthier meat is rich in protein, higher in n-3 fatty acids and lower in n-6 fatty acids; however, to achieve these characteristics, many interrelated factors (genotype, breed, feeding programs, slaughtering, and storage conditions) must interact (Jiménez-Colmenero *et al.,* 2001; Rizwan Tariq *et al.,* 2017). Among these factors, feeding plays an outstanding role in meat quality and composition (Andersen *et al.,* 2005). Rabbit meat offers by nature exceptional nutritive and dietetic properties (Combes,

Table 1. Tropical resources were studied for rabbit feeding.

Scientific name	Published studies	Scientific name	Published studies
Abelmochus esculentus	1	*Tithonia diversifolia*	10
Amaranthus hybridus	5	*Tridax procumbens*	4
Brosimum alicastrum	6	*Salvia hispanica*	3
Carica papaya	5	*Solanum melongena*	1
Chloris gayana	2	*Vigna unguiculata*	1
Cynodon Dactylon	1		
Eleais guineensis	3		
Erythrina poeppigiana	2		
Ficus thoningii	2		
Gliricidia sepium	9		
Helianthus anuus	6		
Ipomea aquatica	2		
Ipomea batatas	4		
Leucaena leucocephala	14		
Macroptilium atropurpureum	1		
Moringa oleifera	15		
Morus alba	10		
Mucuna pruriens	2		
Pennisetum purpureum	3		
Pueraria phaseloides	4		

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2004), like a high amount of protein and low caloric value (Dalle Zotte, 2004).

Digestive physiology of rabbits allows the use of several nutraceutical sources, such as herbs and forages, in their diet, increasing meat quality (Mie *et al.,* 2017; Delis-Hechavarria *et al.,* 2023). Domestic rabbits are one of the most efficient cellulose-converting animal species, ensuring the high production of low-cost meat (Mohamad *et al.,* 2017). The cecotrophy is the physiological process by which the animal can obtain larger quantities of nutrients from herbs and fodder plants and transform them into meat with functional properties; additionally, rabbit meat has several nutritional benefits, including a high protein content and a low cholesterol level (Dalle Zotte and Szendro, 2011; Cullere and Dalle Zotte, 2017). Increases in meat quality, specifically chemical composition and higher content of ω-3 PUFAs, can help to avoid or control different types of diseases and provide some physiological benefits; their main characteristics are to promote the body's healthy condition, to diminish the presence of diseases and to heal some illnesses (Martirosyan *et al.,* 2015). The nutraceutical concept is defined as "a food or part of a food that provides medical or health benefits, including the prevention and/or treatment of a disease" (Santini and Novellino, 2017; Santini and Novellino, 2018). Therefore, the supplementation diet with herbs and fodder plants can be a successful alternative to increase the functional properties of the rabbit meat and other products from different animals (Table 2).

2.2.1 Productive performance

Regarding productive performance, several studies have reported improvements in traits such as daily weight gain (DWG) and feed conversion ratio (FCR); the lowest value for DWG was reported with *Morus* spp. 5.5 g/day and the highest with *Tithonia diversifolia* 47 g/day; for FCR, the lowest value was 2.44 reported with *Delonix regia* and the highest 7.78 with *Carica papaya*; Table 3 presents a resume of results regarding productive performance of rabbits fed different forage sources.

2.2.2 Carcass characteristics

Carcass characteristics are of relevant importance for

Table 2. Chemical composition of tropical resources studied in rabbit feeding.

	DM	CP	CF	FDA	FDN	GE	References
Abelmoschus esculentus	89.80	29.03	18.25	-	-	2.8	Wafar and Tarimbuka (2023)
Amaranthus hybridus	50.48	10.05	15.31	-	-	-	Aliyu (2019)
Brosimum alicastrum	42.5	13.9	22.4	25.5	39.7	4.27	Safwat *et al.* (2014); Carter (2015)
Carica papaya	20.9	25.6	12.5	-	-	4.39	Heuzé and Tran (2015)
Chloris gayana	24.9	9.0	36.9	43.0	75.0	4.3	Mlay *et al.* (2006)
Cynodon dactylon	31.3	9.8	31.3	36.7	66.7	4.3	Campos *et al.* (2010)
Eleais guineensis	91.2	16.7	19.8	44.8	73.0	4.8	Heuzé *et al.* (2016a); Osakwe *et al.* 2007
Erythrina poeppigiana	23.4	25.2	31.3	36.9	51.9	4.4	Heuzé, *et al.* (2019a)
Ficus thoningii	64.32	9.73	18.56	-	-		Aliyu (2019)
Gliricidia sepium	94.50	15.84	-	32.12	41.74	4.7	Heuzé and Tran (2015); Milla – Luna *et al.* (2021).
Helianthus annuus	98.04	22.98	-	-	-	-	Gagour *et al.* (2022)
Ipomea aquatica	13.6	21.4	14.2	23.5	30.1	4.3	Khuc *et al.* (2006)
Ipomea batata	13	16.5	21.1	31.7	42.7	4.37	Dongmeza *et al.* (2009)
Leucaena leucocephala	29.9	23.3	19.9	25.4	40.9	4.53	Heuzé *et al.* (2015b)
Macroptilium atropurpureum	24.4	16.2	34.3	39.5	50.7	4.44	Heuzé *et al.* (2015c)
Moringa oleífera	26.2	24.3	13.6	19.3	28.3	4.44	Heuzé *et al.* (2019)
Morus alba	30.2	19.1	22.3	30.9		4.34	Heuzé *et al.* (2019b)
Mucuna pruriens	24.7	16.0	27.1	34.2	38.5	4.44	Heuzé *et al.* (2015d)
Pennisetum purpureum	17.9	9.7	36.1	42.5	71.5	4.1	Heuzé *et al.* (2020)
Pueraria phaseloides	19.0	19.3	33	38.2	49.4	4.51	Heuzé *et al.* (2017)
Tithonia diversifolia	19.8	21.2	20.2	35.3	44.7	4.22	Heuzé *et al.* (2016)
Tridax procumbens	14.00	15.30	18.45	-	-	2.25	Tsado *et al.* (2012); Anthony *et al.* (2014)
Salvia hispanica	93.2	24.11	34.46	-	-	-	Segura – Campos *et al.* (2014)
Solanum melongenea	26.7	14.04	13.41	-	-	-	Yao *et al.* (2015)
Vigna unguiculata	20.9	18.1	24.1	27.1	38.6	4.32	Heuzé *et al.* (2015)

DM: dry matter, CP: crude protein, CF: crude fibre, ADF: acid detergent fibre, NDF: neutral detergent fiber, GE: gross energy.

Table 3. Daily weight gain and feed conversion ratio in rabbits fed different forage resources.

Author	Species	Inclusion mode	DWG (g)	FCR
Abonyi *et al*. (2012)	*Ipomea batatas*	50% leaf meal	15.47	2.75
Adedeji *et al*. (2013)	*Leucaena leucocephala*	10% leaf meal	18.88	6.88
Adejumo (2006)	*Cassava + leucaena leucocephala+gliricidia sepium*	50%+25%+25% leaf meals	12.32	-
Adeniji and Lawal 2012)	*Moringa oleifera*	60% leaf meal	16.36	4.39
Aderinboye *et al.* (2014)	*Carica papaya*	30% 50% 70%	16 15 13	4.2 4.5 4.7
Akoutey and Kpodekon (2012)	*Pueraria phaseloides*	20%	24.8	3.0
Aliyu (2019)	*Amaranthus hybridus*	Supplement	17.14	4.70
Anthony *et al*. (2014)	*Tridax procumbens*	10%	19.63	2.84
Bamikole *et al*. (2005)	*Morus* spp.	25%	5.15	-
Cardona and Castaño (2015)	*Tithonia diversifolia* *Arachis pintoi* *Trichantera gigantea*	180 g/day	47 44 42	-
Chisowa *et al.* (2013)	*Sesbania seban*	-	6.9	-
Dahouda *et al.* (2013)	*Moringa oleifera*	10% 30%	17.4 17.1	-
Djakalia *et al.* (2011)	*Moringa oleifera*	3%	18	-
Ewuola *et al*. (2012)	*Moringa oleifera*	10%	6.49	-
Fayemi *et al.* (2011)	*Leucaena leucocephala*	Ensiled	17.08	4.41
Fayemi *et al.* (2011)	*Leucaena leucocephala*	10%	15.81	4.92
Franck *et al.* (2016)	*Solanum melongena* *Abelmonchus esculentus* *Vigna unguiculata* *Chorchorus olitorius* *Ipomea batatas*	-	26.29 23.89 24.38 25.73 28.34	5.13 5.71 5.70 5.59 5.67
Kaga (2013)	*Delonix regia*	Seed meal cooked	18.97	2.44
Khuc *et al.* (2006)	Water spinach+*stylo* Water spinach + guinea grass Water spinach + rice bran	Supplement	22.4 23.1 22.0	-
Martínez *et al.* (2005)	Mulberry	48% Substitution		3.1
Martínez – Yáñez *et al.* (2010)	*Hibiscus rosa-sinensis* *Brosimum alicastrum*	Substitution	29.6 30	2.7 2.8
Mora-Valverde (2012)	*Morus alba*	55% inclusion	21.57	2.60
Omole *et al.* (2007)	*Stylosanthes guianensis*	-	7.95	4.93
Oloruntola *et al.* (2015)	*Tridax:pueraria* Elephant grass*:pueraria*	60:40%	11.89 11.58	3.73 3.62
Oloruntola *et al.* (2015)	*Gliricidia sepium*	15% Leaf meal	27.94	2.85
Rohilla and Bujarbaruah (2000)	*Morus alba*	40%	22.76	-
Ukorebi *et al.* (2020)	*Ficus thoningii*	-	11.43	6.43
Saulwa *et al.* (2015	*Carica papaya*	10%	9.87	7.78

the marketing and promotion of consumption, in this sense regarding the use of tropical forages in rabbit meat production, authors such as Uza *et al.* (2020) reported that carcasses of rabbits fed with 5% and 11% inclusion of combined forage of *Cynodon dactylon*, *Gomfrena celesoides,* and *Chloris gayana* presented 12.8 and 15.25% higher carcass yield compared to those that did not include forages, although the results were not statistically significant. For their part, Sánchez-Laiño *et al.* (2018) reported that rabbits fed ad libitum with *Erythrina poeppigiana* obtained a 56% better carcass yield, which represents 11.42% higher carcass yield, compared to rabbits fed with *Morus alba* and *Tithonia diversifolia* ($P<0.05$). Ibrahim (2019) did not find differences in commercial cuts such as the thorax, arms, and legs of rabbits fed with *Amaranthus*, *Tridax procumbens*, fig and melon by-products (*Cucumis melo*); however, in carcass performance, rabbits fed with *Amaranthus* had greater 53.3% ($P<0.05$) compared to those that received other forages. Ekpo (2021) evaluated the use of 20 and 30% of processed *Mucuna pruriens* in the diet and characteristics of the carcass of fattening rabbits, finding that the weight of the carcass (917 g, P<0.05), the percentage of muscle in the carcass (73.68%), the muscle-bone ratio (3.16) and protein content (23.97%) per 100 g of muscle were higher in animals receiving 30% of *Mucuna pruriens*, while the percentage of abdominal fat was 72.62%. Lower for the same treatment; Inclusion of 30% of *Mucuna pruriens* positively impacted the cost/kg produced by being 9% lower compared to the other treatments studied (P<0.05). On the other hand, in this same experiment, he observed that the inclusion of *Mucuna pruriens* in 30% positively modified important characteristics of the carcass, such as the commercial cuts of the arm, legs, loin, and rib cage, in which their weight was greater compared to the commercial feed (P<0.05). On the other hand, Kindossi *et al.* (2021) point out that the meat of rabbits supplemented with *Ipomea aquatica* had 16% greater tenderness, 6.7% greater succulence, and 18.5% greater juiciness, 23.8% greater fibrosity and 12.5% greater general acceptance in a sensory test vs meat from rabbits without supplementation. Amata (2010) reported that inclusion of 5%, 10%, 15% and 20% of *Gliricidia sepium* leaf meal does not have significant effects on carcass characteristics, and García *et al.* (2012) reported that physicochemical characteristics of rabbit meat are not affected by *Gliricidia sepium* inclusion in rabbit feeding. According to Dahouda *et al.* (2013), carcass yield in fattening rabbits improves with the inclusion of 10% and 30% of *Moringa oleifera*. Jiwuba (2018) reported that inclusion of up to 45% of *Carica papaya* leaf meal significantly improved carcass characteristics such as carcass yield, dressing percentage, and loin weight. Jokthan *et al.* (2003) found that using *Ficus thonningii* and *Mangifera indica* leaves produces low DWG 7.62 g and 2.86 g, as well as high FCR 15.9 and 19.05, respectively. Martínez *et al.* (2005) reported that using 48% mulberry in rabbit feeding carcasses resulted in leaner (9 g lipid/kg meat) and higher lumbar circumference than a control diet. Saulawa *et al.* (2015) reported a higher dressed weight of 1053 g with 5% of *Carica papaya* inclusion, as *Carica papaya* inclusion increased, dressed weight decreased progressively. Regarding *Leucaena leucocephala*, Sugur *et al.* (2001) reported that inclusion of Leucaena even in low proportions promotes severe muscular atrophy due to the presence of mimosine.

2.2.3 Protein and fat content

The inclusion of mango seed flour (*Mangifera indica*) as a substitute for 10 and 20% corn, as well as the inclusion of *Pueraria phaseloides* in increasing levels, increased protein content from 2.99 to 6.55%, and zinc content in meat increased from 13.13 to 29% with the inclusion of mango seed flour, while with the inclusion of *Pueraria phaseloides* of 15 and 20% the increase up to 23.90% MS and 22.46% MS respectively. On the other hand, the inclusion of 20% mango flour decreased the fat content in the carcass to 14%. In contrast, the inclusion of *Pueraria phaseloides* increased the fat to 6.67% MS (20% inclusion) and 5.41% MS (25% inclusion). Heuzé *et al.* (2017); Teye *et al.* (2020); Rahman *et al.* (2020) evaluated the use of *Pennisetum purpureum* as an *ad libitum* supplement in combination with 50 and 25% of the commercial feed requirement in fattening rabbits, finding that as the proportion of commercial feed decreased, the weight of meat and bone in the carcass decreased. Proportionally (P<0.05), the author concluded that the use of *Pennisetum purpureum* in rabbits could be an alternative to reduce production costs but not to improve productivity through carcass performance. Molina *et al.* (2018) reported that the use of *Amaranthus dubius* as an alternative feed at 16 and 32% inclusion for fattening rabbits increases the crude protein content by 9.42 and 11.33%, while the fat content in meat increases by 20.6 and 38.77% respectively. In this sense, Wognin *et al.* (2018) reported that protein concentration increases with inclusion of 50% *Vigna unguiculata* plus 50% concentrate; the same author reported that 50% of *Solanum melongenea* increases potassium (546.56 mg/100 g), phosphorus (336.99 mg/100 g) and lysine content in rabbit meat. Selim *et al.* (2021) reported that the use of *Moringa oleifera* as a supplement improves the protein content in rabbit meat (21.74%). Balanceanu *et al.* (2014) reported that the use of different levels of sunflower oil (*Helianthus annuus*) in diets for rabbits had a positive effect on organoleptic characteristics such as aroma, juiciness, and intensity of flavor of the meat; as well as a general increase in carcass fat content and the proportion of dissectible fat. Kindossi *et al.* (2021) reported that meat from rabbits supplemented with *Ipomea aquatica* increased the protein content by 3.01% and the fat content by 24.5%.

2.2.4 Fatty acid profile and oxidative status

According to Decker and Park (2010) and Szendro *et al.* (2010), the content of fatty acids, vitamin E, and selenium can be modified in the rabbit carcass directly through feeding and represents benefits for consumers' health (Adejumo, 2006; Colin *et al.,* 2012); however, it depends on a wide variety of factors. Therefore, the results of research on its modification are very variable in the published literature. Peiretti (2012) reported that the deposition of polyunsaturated fatty acids in the rabbit tissues increases as the amount of chia (*Salvia hispanica*) included in the diet increases without adverse effects on animal performance. For their part, Peiretti and Meineri (2008) reported that the use of *Salvia hispanica* at 10 and 15% inclusion in the diet of growing rabbits promotes an

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increase in PUFA levels in the longissimus dorsi muscle and perirenal fat, 39.25% and 45.36% respectively, with the increase in the chia seed diet while saturated fatty acids decreased 22.9% and 29.7%. Balanceanu *et al.* (2014) reported that the implementation of different levels of diets enriched with sunflower oil (*Helianthus annuus*) showed a positive impact on carcass characteristics and some sensory properties (aroma, juiciness, flavor intensity) due to an increase in the dissectible fat of the carcass and a higher fat content of the meat in general. Teye *et al.* (2020) reported that the use of diets with 25% and 50% inclusion of palm oil residue (*Elaeis guineensis*) in rabbit feeding promoted an n6/n3 fatty acid content up to 32.41% higher than a conventional diet, and up to 30.29% higher content of polyunsaturated fatty acids in meat. Selim *et al.* (2021) reported that the use of *Moringa oleifera* as a supplement improves the concentration of polyunsaturated fatty acids and n-3 fatty acids by 9.63% and 25.21% respectively, when used at a rate of 1.5 g/kg of food. According to authors such as Peiretti (2012); Peiretti and Meineri (2008) point out that supplementation as a strategy to improve n-3 PUFA content is effective, and at the same time promotes a decrease in the n-6/n-3 ratio and consequently saturation values, atherogenic and thrombogenic indexes of meat and fat in the rabbit carcass. Rasinska *et al.* (2018) describe that in rabbit carcass cuts, the best values of PUFA, n6/n3 balance, and nutritional indices are present in the chest and arms, while the legs contain a greater amount of atherogenic saturated fatty acids. Martínez *et al.* (2005) reported that the inclusion of mulberry inclusion 48% promotes a desirable polyunsaturated: saturated ratio w6 (37.3 v. 29.1 g/100 g lipids) and w3 (3.4 v. 2.2 g/100 g lipids). Oloruntola *et al.* (2018) reported that inclusion of 15% of Gliricidia leaf meal in rabbit feeding produces higher superoxide dismutase and glutathione peroxidase concentration, 33.91 and 81.53, respectively. In Table 4, some results about improving carcass characteristics and fatty acid content are presented.

3. Conclusion

Improving carcass quality and rabbit meat composition using forages is viable. The use of forages improves aspects such as bone: muscle ratio, protein content and fatty acid content. The main strategy for inclusion of forage in rabbit feeding is supplementation. *Moringa oleifera* is the tropical forage species that has been most studied for feeding rabbits worldwide.

Conflict of interest

The authors declare no conflict of interest.

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Table 4. Effects of tropical resources on rabbit carcass characteristics and fatty acid content.

Species	Improved trait	Improvement level	Level of inclusion	Autor
Moringa oleífera	Polyunsaturated fatty acids n-3 Fatty acids PUFA: SFA Crude protein content	4.13 – 7.7% 19.58 – 25.21% 2.59 – 9.6% 3.80 – 5.88%	0.5 – 1.5%	Selim *et al.* (2021)
Eleais guineensis	n-3 / n-6 Fatty acids	67.58%	20 – 25%	Teye *et al.* (2020)
Salvia hispanica	Polyunsaturated fatty acids	39.25 – 45.36%	10 – 15%	Peiretti and Meineri (2008)
Erythrina poeppigiana	Carcass yield	56%	*Ad libitum*	Sánchez Laiño *et al.* (2018)
Amaranthus	Carcass yield	53.3%		Ibrahim (2019)
Mucuna pruriens	Carcass muscle content increase, muscle: bone ratio and protein content Abdominal fat content decreases Feeding cost decreases	3%	30%	Ekpo (2021)
Mangifera indica (seed)	Zinc and protein content	28.2% and 6.6%	20%	Teye *et al.* (2020)
Pueraria phaseloides	Crude protein content	23.9 6.5	15%	Thiam *et al.*(2021)
	Fat content decreases	22.46 5.41	20%	
Amaranthus dubius	Protein and fat content increase			Molina *et al.* (2018)
Cynodon dactylon, *Gomfrena celesoides* *Chloris gayana*	Carcass yield increase	12.8 15.25	5% 11%	Uza *et al.* (2020)
Ipomea aquatica	Crude protein content increases	3.01		Kindossi *et al.* (2021)

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