Trends in Applied Sciences Research

ISSN 1819-3579

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS Trends in Applied Sciences Research

ISSN 1819-3579
DOI: 10.3923/tasr.2019.226.232

Review Article
Effect of Grape Pomace Inclusion on the Production and Quality of Sheep Meat

Diego Rafael Martins Flores, Patricia Alves da Fonseca and José Laerte Nörnberg

Department of Food Science and Technology, Federal University of Santa Maria, Roraima Avenue, 1000, Santa Maria, RS, Brazil

Abstract
Sheep farming is a prominent activity in Brazil and it provides the lower profit margins to the rural producer in extensive systems. Innovations in animal nutrition have shown alternative sources to improve the quality of food products. Grape pomace (GP) is a byproduct from winemaking used as feed for ruminants, with few studies on the quality of sheep meat. Thus, this study aimed to discuss the main characteristics of grape pomace, its relationship with the production, fatty acid profile and oxidative stability of sheep meat. The destination of GP as an agro-industrial residue is a concern in the winemaking industries, leading to the search for alternatives with low cost and high potential for use in animal feed. The GP is offered in various forms to animals, but the knowledge about its composition is required to explore its nutritional potential with no intoxication risks. Concerning the carcass characteristics, the productive performance of the animals can be favored with the use of GP in diet. The fatty acid profile of sheep meat plays a key role and in this context is modified in several ways. The GP can act on ruminal biohydrogenation, altering the fatty acid profile of meat. In addition, the GP supplementation may increase the oxidative stability of meat due to the presence of phenolic compounds.

Key words: Ruminal biohydrogenation, sheep farming, agro-industrial residue, grape pomace, performance, meat quality

Citation: Diego Rafael Martins Flores, Patricia Alves da Fonseca and José Laerte Nörnberg, 2019. Effect of grape pomace inclusion on the production and quality of sheep meat. Trends Applied Sci. Res., 14: 226-232.

Corresponding Author: Diego Rafael Martins Flores, Department of Food Science and Technology, Federal University of Santa Maria, Roraima Avenue, 1000, Santa Maria, RS, Brazil

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sheep farming are a prominent activity in Brazil, with approximately 15 million animals distributed throughout the country, mainly in the south, northeast and central-west regions[1,2]. However, extensive sheep farming offers relatively small profit margins to the producer, thus there is a need to remodel the management and feeding costs[3,4].

Innovations in the area of animal production and meat quality have sought technological alternatives using surplus resources, in addition to reducing costs and adding value to products[5]. In this context, the searches for alternative foods is necessary to be used in a ruminant diet, once herd nutrition expenses account for about 50-70% of the production costs[6].

As observed in the livestock activity, the southern region of Brazil have shown a significant and marked increase in winemaking activity in recent years, increasing the by-product generation due to grape processing[7]. Due to the presence of bioactive compounds, presents in byproducts of the wine industry used in animal diet, the oxidative stability and the quality of meat can increase[8].

Studies on the use of grape pomace (GP) in ruminant feed have focused on metabolism, productive performance and milk quality[9,11]. Guerra-Rivas *et al.*[12] and Jeronimo *et al.*[13] provided information on the use of grape pomace in the diet of sheep with respect to the fatty acid profile and oxidative stability of meat. Therefore, this study was aimed to discuss the main characteristics of grape pomace, its relationship with the production, fatty acid profile and oxidative stability of sheep meat.

GRAPE POMACE IN SHEEP FEED

According to the Brazilian Wine Institute, the largest producing regions are located in the northeast and south Brazilian regions[14]. The main grape-growing areas established in the south region produce red and white grapes[15]. The amount of grape production in south region of Brazil is shown in Table 1.

The concern of the industry and the ethical and environmental issues have led to more demanding production chains about the generation and marketing of agro-industrial waste[16]. The Brazilian winemaking has searched for the proper destination of residues, once about 12-15% of the initial raw material of grape production is by-products[17]. Although the wineries generate biodegradable waste, they require a minimum time for degradation of the residual biomass, constituting a source of pollutants[18,20].

Ruminant farming characterized by feeding on natural pastures in the world and traditionally carried out by an extensive production system. However, high production rates is affected by food deficits. Thus, the use of food alternatives for breeders to address the nutritional deficiency of herds, such as hay, silage and agro-industrial residues have been recommended[10].

The great demand for food substitution in animal nutrition, which contain nutrients that is converted into noble products such as; meat, intensified the use of plant raw materials[21]. New food sources in sheep diet has been studied with the use of poultry litter, residues of various fruits and legumes and residues from the production of olive oil and grape[12,22-25].

The GP was supplied to animals after drying, in the form of meal or extract. In addition, due to its high moisture content and for maintaining its nutritional quality, GP was ensiled and stored for longer periods[26]. The GP is composed of stalks, pulp (bark and seed) and lees containing pre-dominantly total carbohydrates, water (60-70%) and proteins[27], besides pigments, alcohols, volatile acids, tannins, phenolic compounds, pectins and fibers[28,29]. The seeds also have about 15-20% of polyunsaturated fatty acids rich in omega-3 and[30] omega-6.

As shown in Table 2, several factors including the production and management of the grape vines, cultivars used, proportion of grapes and maturation in the harvest period there related to great variability in the proximate composition of GP[31].

Due to its high levels of fibrous carbohydrates, GP can be included in the bulk fraction of the ruminant and monogastric diet as a food substitute or food supplement[32]. In contrast, the amount offered to the animals should be evaluated, especially due to the high levels of lignified fiber and copper (Cu), which

Table 1: Amount of grape production in south region of Brazil (millions kg)

Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017*
White	68,8	60,6	58,5	78,8	78,6	66,3	58,8	79,1	28,3	40
Rosé	15,1	10,5	13,1	15,3	14,9	10,8	9,9	16,2	4,4	10
Red	466,4	391	409,2	532,8	527,1	460,2	471,3	537,2	235,3	550
Total	550,3	462,1	480,8	626,9	620,6	537,3	540,1	632,5	268	600

Source: BWI[14] and MAPA[15], *Estimated data

Table 2: Chemical composition of grape pomace

References	DM (%)	CP (DM %)	EE (DM %)	MM (DM %)	CF (DM %)
Basalan *et al.*[36]	29-31	7-8	1.5-8	4.5-5	37-43
Santos[37]	33	27	11	6.5	50
Yu and Ahmedna[38]	50-60	11	13-19	-	20-25
Dall Asta[39]	19-28	14-11.8	6.7-7.9	6-11.5	56-59
Oliveira *et al.*[40]	49	5	7.5	2.5-4	5-15
Sousa *et al.*[41]	30	8.5	8	4.5	46

DM: Dry matter, CP: Crude protein, EE: Ether extract, MM: Mineral matter, CF: Crude fiber

can negatively affect the digestibility of nutrients[33], reaching toxic levels[34]. Generally, the cupric treatments for pest control of grape wines related to high Cu levels in GP[35].

Sheep, unlike other species are most susceptible to copper toxicity, requiring special care in animal nutrition[42,43]. Small ruminants require a daily dose of 5-10 mg kg^{-1} cooper in dry matter (DM), not tolerating diets containing more than 15 mg kg^{-1} copper[44-47].

PRODUCTIVE PERFORMANCE

The animal performance including the voluntary consumption and food digestibility influenced by factors related to both the individual and food. New food sources, such as; agro industrial residues, required studies on the composition and digestibility for proper use in animal nutrition[48].

The productive performance of ruminants assessed by weight gain and feed conversion. In a complementary way, *in vitro* and *in vivo* digestion methods provided accurate, simple and complete information about the quality of food supplied to ruminants[49,50].

Researcher was reported the effective results about the chemical composition, *in vivo* digestibility and ruminal degradation of GP concerning the percentage of inclusion of GP in the diet of sheep[34]. In agreement, Bahrami *et al.*[51] studied the addition of 0-20% of grape residue in the diet of small ruminants and found greater *in vivo* dry matter digestibility, protein and neutral detergent fiber in the groups fed 5-10%, which were more adequate levels for the fattening and finishing of lambs.

Food supplementation is necessary for production animals, especially in the search for greater weight gain, slaughter precocity and carcass quality[52]. These characteristics directly related to the final product are also an important tool for evaluating animal performance. A single study reported the use of grape residue in ruminant feed and its effect on the carcass characteristics, with no significant differences in the finishing score, fat thickness, marbling and carcass yield of lambs, when compared to the groups that did not feed GP[53].

QUALITY OF SHEEP MEAT

Global meat consumption has undergone several changes over the last few years. In the 1990's, there were price-related trends while other parameters including appearance, safety and health benefits have stood out more recently[54,55].

Meat are a great source of high-quality protein, rich in minerals and vitamins and its fat is an excellent source of essential fatty acids for the human diet[56,57]. Although different factors can affect the meat quality, such as; genetics and breeding, meat can exhibited high quality and degree of excellence[58].

FATTY ACIDS PROFILE

Fatty acids are a class of macronutrients with great biological activity in cells and tissues and can be classified by the number of carbon atoms and the number of double bonds in their structure[58,59]. The main saturated fatty acids founded in sheep meat are myristic, palmitic and stearic acids, the monounsaturated fatty acids are palmitoleic and oleic acids and the polyunsaturated fatty acids include the linoleic, linolenic and arachidonic acids[60,61].

Ruminants have efficient absorption of saturated fatty acids due to the great capacity of bile salts and the micellar system of lysophospholipids that solubilize fatty acids[62]. However, the lipid biohydrogenation of dietary lipids determined by the effect of polyunsaturated fatty acids alters the muscle composition in ruminants[63]. Through the biohydrogenation, the microbial enzymes promote isomerization and hydrolysis of unsaturated fatty acids, allowing the formation of trans fatty acids[64].

Diets rich in bioactive compounds have demonstrated an ability to manipulate ruminal biohydrogenation through modifications in the ruminal microbiota[65]. Specifically, flavonoids, phenolic acids and tannins[66] found in grape by-products may inhibit the activity of micro-organisms that are involved in the biohydrogenation of polyunsaturated fatty acids, allowing their accumulation and release to muscles and fats[67].

The inclusion of grape residue in ruminant feed can significantly increase the poly and mono-unsaturated fatty acids, such as vaccenic acid[68], linolenic acid[69] and conjugated linoleic acid in milk[70]. However, Maciel[53] studied the fatty acid profile of meat from ruminants fed GP and found a significant increase in linolenic acid in the meat of GP-terminated lambs.

Oxidation reactions: Fatty acids are related to several meat quality parameters, including color, texture and the appearance of meat fat[71]. One of the traditional ways to modify the fatty acids composition in meat is the use of vegetable oils in the diet[72,73]. Linseed, sunflower and flax oils are abundant sources of unsaturated fatty acid from the omega-3 and 6 families[74,75]. However, unsaturated fatty acids are susceptible to rapid oxidation due to the presence of two or more double bonds in their structure, making it an important regulator of the shelf life of meat[76,77].

The oxidative process can shortened the shelf life of fats and fresh meat, negatively affecting its consumption due to the formation of off-flavors and discoloration[78]. In addition, the protein oxidation has negative effects on the nutritional value and sensory attributes of meat, such as texture[79].

The oxidation rate is determined by storage conditions such as temperature, the presence of oxygen and light and by the levels of unsaturated fatty acids and metal ions of meat[80]. Oxidation reactions through the presence of antioxidant compounds in tissues are prevented or delayed[81], once these compounds counterbalance the oxidation reactions, preventing the reactive oxygen species generation and decomposition of various peroxides[82].

Several plant materials used in the ruminant diet are generous sources of phenolic compounds, which can be considered as natural antioxidants to preserve and improve the quality of meat[83,84]. These compounds, besides having a recognized antioxidant action, confer health benefits in humans, modulating the inflammatory response and circulatory disorders[85,86]. The residues from winemaking and grape-juice industries are rich sources of phenolic compounds, particularly mono, oligo and polymeric anthocyanins[87,88]. Grape seeds and bark have higher antioxidant compounds levels, including flavonoids, stilbenes, phenolic acids as well as a wide variety of tannins[89,90].

The evaluation of ruminant meat, regarding the use of grape residue in diet has demonstrated positive effects against the lipid oxidation. Guerra-Rivas *et al.*[12] reported similar lipid oxidation in the meat of lambs fed GP when compared to the treatments that received vitamin E supplementation, while Jeronimo *et al.*[13] demonstrated that supplementation of lambs with GP protected meat against lipid oxidation while maintaining the sensory properties.

CONCLUSION

The inclusion of grape pomace in sheep feed improved the production system, by reducing the costs to the producer and avoiding the disposal of byproducts with negative effects on the environment. The grape pomace has important functional characteristics, which brings benefits to the productive performance and meat production when used in animal feed. However, its composition are variable, thus it is necessary to predict its nutritional profile for an adequate supply in sheep nutrition. Grape pomace modulated the fatty acids deposition and enhanced the oxidative stability of meat.

SIGNIFICANCE STATEMENT

This study demonstrates that there are adequate levels of the use of grape pomace silage in sheep feed. Levels more suited to the needs of animals, can prevent poisoning and benefit the meat of this animals. This study may help new research in these fields, leading to more effective work in the search of economic benefits to the productive sector.

REFERENCES

1. Souza, I.G., 2005. The Sheep-Practical and Zootechnical Manual. 2nd Edn., Palloti, India, pp: 6-10.
2. MAPA., 2018. Desculpe, mas esta pagina nao existe. Ministerio da Agricultura, Pecuaria e Abastecimento, Brasilia. http:// www. agricultura.gov. br/vegetal/culturas/uva
3. Barros , C.S. , A.L.G. Monteiro, C.H.E.C. Poli, J.R. Dittrich, J.R.F. Canziani and M.A.M. Fernandes, 2009. Profitability of pasture and confinement sheep production. Brazil. J. Anim. Sci., 38: 2270-2279.
4. Decker, S.R.F., D.A.C. Fernandes and M.C. Gomes, 2016. Competitive management in sheep production. Agropampa, Vol. 1.
5. Sereia, V.J., E. Stal and M.R.G. Camara, 2015. Determinants of innovation in meat agroindustrial industries. Economy, 25: 647-672.
6. Volpato, R.M., V. de Oliveira, C.E. Gewehr and D.P. Neto, 2015. Coproducts of agroindustry in piglets feeding. Rural Sci., 45: 86-91.
7. Mattei, L. and V. Triches, 2016. Analysis of the competitiveness of the wine sector of Rio Grande do Sul. Qualitas Elect. J., Vol. 17.
8. Brenes, A., A. Viveros, S. Chamorro and I. Arija, 2016. Use of polyphenol-rich grape by-products in monogastric nutrition. A review. Anim. Feed Sci. Technol., 211: 1-17.
9. Kafantaris, I., B. Kotsampasi, V. Christodoulou, E. Kokka and P. Kouka *et al.*, 2017. Grape pomace improves antioxidant capacity and faecal microflora of lambs. J. Anim. Physiol. Anim. Nutr., 101: e108-e121.

10. Manera, D.B., T.V. Voltolini, S.M. Yamamoto, G.G.L. de Araujo and R.A. Souza, 2014. Productive performance lambs on grazing supplemented with concentrates containing fruit processing by-products. Semina: Ciencias Agrarias, 35: 1013-1022.
11. Barroso, D.D., G.G.L. de Araujo, D.S. da Silva and F.T. Medina, 2006. Dehydrated vineyard residue associated to different energy sources in sheep feed: Apparent consumption and digestibility. Sci. Agrotechnol., 30: 767-773.
12. Guerra-Rivas, C., C. Vieira, B. Rubio, B. Martinez and B. Gallardo *et al*., 2016. Effects of grape pomace in growing lamb diets compared with vitamin E and grape seed extract on meat shelf life. Meat Sci., 116: 221-229.
13. Jeronimo, E., C.M. Alfaia, S.P. Alves, M.T. Dentinho and J.A. Prates *et al*., 2012. Effect of dietary grape seed extract and *Cistus ladanifer* L. in combination with vegetable oil supplementation on lamb meat quality. Meat Sci., 92: 841-847.
14. BWI., 2018. Brazil-producing regions. Brazilian Wine Institute, Brazil. https://www.ibravin.org.br/Regioes-Produtoras
15. MAPA., 2016. Desculpe, mas esta pagina nao existe. Ministerio da Agricultura, Pecuaria e Abastecimento. http://www.agricultura.gov.br/comunicacao/noticias/2016/04/producao-de-carne-no-brasil-aumenta-45porcento-em-15-anos
16. Schenini, P.C., 2011. Agro-industry waste management. Proceedings of The 2nd International Symposium on Agricultural and Agroindustrial Waste Management, March 15-17, 2011, SIGERA., Foz do Iguacu, PR.
17. Larrauri, J.A., P. Ruperez and F.S. Calixto, 1996. Antioxidant activity of wine pomace. Am. J. Enol. Viticult., 47: 369-372.
18. Casagrande, M., 2014. Evaluation of the antioxidant potential of co-products of grape juice and wine industries for their application in chicken sausage. Technology Federal University of Parana, pp: 1-121.
19. Huber, K., J.H. de Queiroz, A.V.B. Moreira and S.M.R. Ribeiro, 2012. Chemical characterization of agricultural by-products from UBA mango (*Mangifera indica* L.): A perspective for obtaning natural antioxidants. Brazil. J. Agroindust. Technol., 6: 640-654.
20. Murga, R., R. Ruiz, S. Beltran and J.L. Cabezas, 2000. Extraction of natural complex phenols and tannins from grape seeds by using supercritical mixtures of carbon dioxide and alcohol. J. Agric. Food Chem., 48: 3408-3412.
21. Oliveira, A.C., I.B. Valentim, M.O.F. Goulart, C.A. Silva, E.J.H. Bechara and M.T.S. Trevisan, 2009. Vegetals as natural sources of antioxidants. New Chem., 32: 689-702.
22. Gravador, R.S. , A. Serra, G. Luciano, P. Pennisi and V. Vasta *et al*., 2015. Volatiles in raw and cooked meat from lambs fed olive cake and linseed. Animal, 9: 715-722.
23. Almeida, J.C.S., D.M. de Figueiredo, C.A. Boari, M.L. Paixao and J.A.B. Sena *et al*., 2015. Performance, body measurements, carcass and cut yields and meat quality in lambs fed residues from processing agroindustry of fruit. Semina: Agrarian Sci., 36: 541-556.
24. Trujillo, G.D., G.J. Borquez, J.M. Pinos-Rodriguez, I.A. Dominguez-Vara and R.R. Rojo, 2014. Nutritive value of ensiled pig excreta, poultry litter or urea with molasses or bakery by-products in diets for lambs. S. Afr. J. Anim. Sci., 44: 114-122.
25. Timariu, S., M. Stoicea, D. Petcu, A. Calotoiu, V. Tascenko and G. Ionescu, 1965. Grape residues and vine shoots in animal feeding. Lucrarile Stiintif. Ale Inst. Cercetari Zoot., 22 22: 103-120.
26. Woolford, M.K. and G. Pahlow, 1998. The Silage Fermentation. In: Microbiology of Fermented Foods, Wood, B.J.B. (Ed.)., Springer, Germany, pp: 73-102.
27. Barroso, D.D., 2005. Dehydrated residue of vitinicola from the Sao Francisco valley associated to different energy sources for sheep finished in confinement. Master's Thesis, Federal University of Paraiba.
28. Rotava, R., I. Zanella, L.P. Silva, M.P. Manfron and C.S. Ceron *et al*., 2009. Antibacterial, antioxidant and tanning activity of grape by-product. Ciencia Rural, 39: 941-944.
29. Orriols, I., 1994. Distillation technology in grape residues. Proceedings of the Ist International Congress of Atlantic Viticulture, (AV'94), Research Institute of Organic Agriculture, pp: 291-305.
30. FAO., 2011. Utilization of fruit and vegetable wastes as livestock feed and as substrates for generation of other value added products. Foods and Agricultural Organization of the United Nation, Italy.
31. Can, A., N. Denek and S. Tufenk, 2004. Effect of different additives on silage quality and *in vitro* dry matter digestibility of wet grape pomace. J. Agric., 8: 11-15.
32. Monteiro, A.V., F.M. Goncalves, R.A. Pereira, J.M. Brustolin, F.P. Amaral, J. Halfen and M.N. Correa, 2015. Microbiological analysis of winers co-products with potential for use in ruminant feeding. Sci. Anim. Health, 3: 65-77.
33. Nornberg, J.L., I.L. Brondani, L. Cerdotes and C.D.O. Carrilho, 2002. Chemical-bromatological characteristics of grape pomace silage. Proceedings of the Annual Meeting of the Brazilian Zootechny, (BZ'02), Brazil, pp: 39.
34. Guerra Rivas, C., B. Gallardo, A.R. Mantecon, M. del Alamo-Sanza and T. Manso, 2017. Evaluation of grape pomace from red wine by product as feed for sheep. J. Sci. Food Agric., 97: 1885-1893.
35. Fidelis, Jr., O.L., P.H. Sampaio, P.P.M. Teixeira, L.C.N. Mendes and F.A. Cadioli, 2013. Cupric poisoning in sheep: Literature review. Nucleus Animalium, 5: 63-72.
36. Basalan, M., T. Gungor, F.N. Owens and I. Yalcinkaya, 2011. Nutrient content and *in vitro* digestibility of Turkish grape pomaces. Anim. Feed Sci. Technol., 169: 194-198.
37. Santos, N.W., 2011. Grape pomace silage as source of antioxidant in diets with soybean oil for dairy cows. Master's Thesis, State University of Maringa, Brazil.
38. Yu, J. and M. Ahmedna, 2013. Functional components of grape pomace: Their composition, biological properties and potential applications. Int. J. Food Sci. Technol., 48: 221-237.

39. Dall Asta, F.S., 2015. Grape pomace: Alternative in the diet of ruminants-bromatological profile of silages of different cultivars. Proceedings of Annals of the VII International Salon of Teaching, Research and Extension, (STRE'15), Federal Universty of Pampa, Brazil.
40. Oliveira, R.M., F.M. Oliveira, J.V. Hernandes and A.C. Jacques, 2016. [Centesimal composition of grape flour made with residue from the wine industry]. Rev. CSBEA, Vol. 2, No. 1, (In Portuguese).
41. Sousa, E.C., A.M.A. Uchoa-Thomaz, J.O.B. Carioca, S.M. de Morais and A. de Lima*et al*., 2014. Chemical composition and bioactive compounds of grape pomace (*Vitis vinifera* L.), Benitaka variety, grown in the semiarid region of Northeast Brazil. Food Sci. Technol. (Campinas), 34: 135-142.
42. Reis, M.D.O., L.S. Mello, R.A.S. da Cruz, L.L. Guimaraes and L.G.S. de Oliveira *et al*., 2015. Chronic copper toxicity in sheep fed grape marc. Acta Sci. Vet., Vol. 43.
43. Camara, A.C.L., R.G. Olinda, L. Dalcin, I.C.N. Gadelha, J.S. Batista and B. Soto-Blanco, 2016. Accumulative copper poisoning in sheep in Northeastern Brazil. Acta Sci. Vet., Vol. 44.
44. Suttle, N., 2010. Copper. In: Mineral Nutrition of Livestock, Suttle, N. (Ed.). 4th Edn., Chapter 11, CABI, Oxford, UK., ISBN-13: 9781845934729, pp: 255-306.
45. Ribeiro, C.D.S.G. and M. Corcao, 2013. The consumption of meat in Brazil: Between socio-cultural and nutritional values. Demetra: Food Nutr. Health, 8: 425-437.
46. Vasquez, E.F.A., A.P.N. Herrera and G.S. Santiago, 2001. [Copper, molybdenum and sulphur interaction in ruminant nutrition]. Rural Sci., 31: 1101-1106, (In Portugues).
47. Barcelos, J.O.J. and H.P. Ospina, 1998. Copper. In: Mineral Nutrition in Ruminants, Gonzalez, F.H.D., H. Opina and J.O.J. Barcellos (Eds.). 2nd Edn., UFRGS Press, Porto Alegre, Brazil, pp: 227.
48. Branco, A.F., S.M. Coneglian, F.J. Maia and K.C. Guimaraes, 2006. [True small intestinal protein digestibility of ruminant feeds]. Braz. J. Anim. Sci., 35: 1788-1795, (In Portuguese).
49. Almaraz, I., S.S. Gonzalez, J.M. Pinos-Rodriguez and L.A. Miranda, 2010. Effects of exogenous fibrolytic enzymes on in sacco and *in vitro* degradation of diets and on growth performance of lambs. Ital. J. Anim. Sci., Vol. 9, No. 1. 10.4081/ijas.2010.e2.
50. Campos, P.R.S.S., S.C.V. Filho, P.R. Cecon, E. Detmann and M.I. Leao*et al*., 2006. Comparative study of ruminal degradation kinetics of tropical forages in cattle and sheep. Arq. Bras. Med. Vet. Zootec., 58: 1181-1191.
51. Bahrami, Y., A.D. Foroozandeh, F. Zamani , M. Modarresi, S. Eghbal-Saeid and S. Chekani-Azar, 2010. Effect of diet with varying levels of dried grape pomace on dry matter digestibility and growth performance of male lambs. J. Anim. Plant Sci., 6: 605-610.
52. Nobre, I.S., B.B. de Souza, B.A.A. Marques, A.M. de Azevedo and R.P. Araujo *et al*., 2016. [Evaluation of levels of fat protected and concentrate on productive performance and sheep thermoregulation]. Braz. J. Anim. Health Prod., 17: 116-126, (In Portuguese)..
53. Maciel, M.B., 2012. [Inclusion levels of grape pomace silage in the feeding of lambs in the finishing phase]. Ph.D. Thesis, Federal University of Santa Maria, Brazil, (In Portuguese).
54. Mortimer, S.I., J.H.J. van der Werf, R.H. Jacob, D.L. Hopkins and L. Pannier *et al*., 2014. Genetic parameters for meat quality traits of Australian lamb meat. Meat Sci., 96: 1016-1024.
55. Bernabeu, R. and A. Tendero, 2005. Preference structure for lamb meat consumers. A Spanish case study. Meat Sci., 71: 464-470.
56. Cabrera, M.C. and A. Saadoun, 2014. An overview of the nutritional value of beef and lamb meat from South America. Meat Sci., 98: 435-444.
57. Givens, D.I., 2005. The role of animal nutrition in improving the nutritive value of animal-derived foods in relation to chronic disease. Proc. Nutr. Soc., 64: 395-402.
58. Sinclair, L.A., 2007. Nutritional manipulation of the fatty acid composition of sheep meat: A review. J. Agric. Sci., 145: 419-434.
59. Lorente-Cebrian, S., A.G. Costa, S. Navas-Carretero, M. Zabala, J.A. Martinez and M.J. Moreno-Aliaga, 2013. Role of omega-3 fatty acids in obesity, metabolic syndrome and cardiovascular diseases: A review of the evidence. J. Physiol. Biochem., 69: 633-651.
60. Fuke, G. and J.L. Nornberg, 2017. Systematic evaluation on the effectiveness of conjugated linoleic acid in human health. Crit. Rev. Food Sci. Nutr., 57: 1-7.
61. Senegalhe, F.B.D., P.C. Burin, I.H.S. Fuzikawa, D.S. Penha and A.P. Leonardo, 2014. Fatty acids in the meat and fat of sheep. Encycl. Biosphere, 10: 80-101.
62. Fruet, A.P.B., F. Trombetta, F.S. Stefanello, C.S. Speroni and J.Z. Donadel *et al*., 2018. Effects of feeding legume-grass pasture and different concentrate levels on fatty acid profile, volatile compounds and o ff-flavor of the *M. longissimus* thoracis. Meat Sci., 140: 112-118.
63. Pereira, P.M.D.C.C. and A.F.D.R.B. Vicente, 2013. Meat nutritional composition and nutritive role in the human diet. Meat Sci., 93: 586-592.
64. Durand, D., V. Scislowski, D. Gruffat, Y. Chilliard and D. Bauchart, 2005. High-Fat Rations and Lipid Peroxidation in Ruminants: Consequences on the Health of Animals and Quality of their Products. In: Indicators of Milk and Beef Quality, Hocquette, J.F. and S. Gigli (Eds.). Wageningen Academic Publishers, Netherlands, ISBN: 978-90-76998-48-0, pp: 137-150.

65. Scollan, N.D., D. Dannenberger, K. Nuernberg, I. Richardson, S. MacKintosh, J.F. Hocquette and A.P. Moloney, 2014. Enhancing the nutritional and health value of beef lipids and their relationship with meat quality. Meat Sci., 97: 384-394.
66. Correddu, F., G. Gaspa, G. Pulina and A. Nudda, 2016. Grape seed and linseed, alone and in combination, enhance unsaturated fatty acids in the milk of Sarda dairy sheep. J. Dairy Sci., 99: 1725-1735.
67. Balasundram, N., K. Sundram and S. Samman, 2006. Phenolic compounds in plants and agri-industrial by-products: Antioxidant activity, occurrence and potential uses. Food Chem., 99: 191-203.
68. Buccioni, A., M. Pauselli, C. Viti, S. Minieri and G. Pallara *et al*., 2015. Milk fatty acid composition, rumen microbial population and animal performances in response to diets rich in linoleic acid supplemented with chestnut or quebracho tannins in dairy ewes. J. Dairy Sci., 98: 1145-1156.
69. Correddu , F., A. Nudda, G. Battacone, R. Boe, A.H.D. Francesconi and G. Pulina, 2015. Effects of grape seed supplementation, alone or associated with linseed, on ruminal metabolism in Sarda dairy sheep. Anim. Feed Sci. Technol., 199: 61-72.
70. Santos, N.W., G.T.D. Santos, D.C. Silva-Kazama, P.A. Grande and P.M. Pintro*et al*., 2014. Production, composition and antioxidants in milk of dairy cows fed diets containing soybean oil and grape residue silage. Livest. Sci., 159: 37-45.
71. Tsiplakou, E. and G. Zervas, 2008. The effect of dietary inclusion of olive tree leaves and grape marc on the content of conjugated linoleic acid and vaccenic acid in the milk of dairy sheep and goats. J. Dairy Res., 75: 270-278.
72. Wood, J.D., M. Enser, A.V. Fisher, G.R. Nute and P.R. Sheard *et al*., 2008. Fat deposition, fatty acid composition and meat quality: A review. Meat Sci., 78: 343-358.
73. Martin , C.A., V.V. de Almeida, M.R. Ruiz, J.E.L. Visentainer, M. Matshushita, N.E. de Souza and J.V. Visentainer, 2006. [Omega-3 and omega-6 polyunsaturated fatty acids: Importance and occurrence in foods]. J. Nutr., 19: 761-770, (In Portuguese).
74. Fruet, A.P.B., F.S. Stefanello, A.G. Rosado Jr., A.N.M. de Souza, C.J. Tonetto and J.L. Nornberg, 2016. Whole grains in the finishing of culled ewes in pasture or feedlot: Performance, carcass characteristics and meat quality. Meat Sci., 113: 97-103.
75. Rosa, B.R., 2014. [Linseed oil in the diet of Nelore x Canchim castrated females and males, finished in confinement]. Ph.D. Thesis, Faculty of Agrarian and Veterinary Sciences, Paulista State University, Brazil, (In Portuguese).
76. Bozan, B. and F. Temelli, 2008. Chemical composition and oxidative stability of flax, safflower and poppy seed and seed oils. Bioresour. Technol., 99: 6354-6359.
77. Wood, J.D., R.I. Richardson, G.R. Nute, A.V. Fisher and M.M. Campo *et al*., 2004. Effects of fatty acids on meat quality: A review. Meat Sci., 66: 21-32.
78. Fruet, A.P.B. , A. de Mello, F. Trombetta, F.S. Stefanello and C.S. Speroni *et al*., 2018. Oxidative stability of beef from steers finished exclusively with concentrate, supplemented, or on legume-grass pasture. Meat Sci., 145: 121-126.
79. Falowo, A.B., P.O. Fayemi and V. Muchenje, 2014. Natural antioxidants against lipid-protein oxidative deterioration in meat and meat products: A review. Food Res. Int., 64: 171-181.
80. Zhang, W., S. Xiao and D.U. Ahn, 2013. Protein oxidation: Basic principles and implications for meat quality. Crit. Rev. Food Sci. Nutr., 53: 1191-1201.
81. Frankel, E.N., 2014. Oxidation in Multiphase Systems. In: Lipid Oxidation, Frankel, E.N. (Ed.). 2nd Edn., Woodhead Publishing, USA., ISBN-13: 9780857097927, pp: 259-299.
82. Forman, H.J., K.J.A. Davies and F. Ursini, 2014. How do nutritional antioxidants really work: Nucleophilic tone and para-hormesis versus free radical scavenging *in vivo*. Free Radic. Biol. Med., 66: 24-35.
83. Birben, E., U.M. Sahiner , C. Sackesen, S. Erzurum and O. Kalayci, 2012. Oxidative stress and antioxidant defense. World Allergy Organiz. J., 5: 9-19.
84. Shah, M.A., S.J.D. Bosco and S.A. Mir, 2014. Plant extracts as natural antioxidants in meat and meat products. Meat Sci., 98: 21-33.
85. Manach, C., A. Scalbert, C. Morand, C. Remesy and L. Jimenez, 2004. Polyphenols: Food sources and bioavailability. J. Clin. Nutr., 79: 727-747.
86. Ky, I., B. Lorrain, N. Kolbas, A. Crozier and P.L. Teissedre, 2014. Wine by-products: Phenolic characterization and antioxidant activity evaluation of grapes and grape pomaces from six different French grape varieties. Molecules, 19: 482-506.
87. Moure, A., J.M. Cruz, D. Franco, J.M. Dominguez and J. Sineiro*et al*., 2001. Natural antioxidants from residual sources. Food Chem., 72: 145-171.
88. Schieber, A., F.C. Stintzing and R. Carle, 2001. By-products of plant food processing as a source of functional compounds-recent developments. Trends Food Sci. Technol., 12: 401-413.
89. Torres, J.L. and R. Bobet, 2001. New flavanol derivatives from grape (*Vitis vinifera*) byproducts. Antioxidant aminoethylthio-flavan-3-ol conjugates from a polymeric waste fraction used as a source of flavanols. J. Agric. Food Chem., 49: 4627-4634.
90. Pires, A.P.M., 2010. [Chemical composition and antioxidant activity of leaves of different wine varieties]. Master's Thesis, Escola Superior Agraria, Instituto Politecnica de Braganca, Portugal, (In Portuguese).