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The Use of Pomace as Animal Feed: A Review of Grape and Tomato Pomace

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Abstract

Pomace is generated in large quantities yearly; high water content and bulkiness make it difficult to be easily disposed of thereby contributing to environmental pollution and providing breeding space for flies which can transmit diseases. Incorporating the pomace generated from grape and tomato fruits in animal nutrition will improve sustainable agriculture; the animals will also benefit from the polyphenols in the pomace which can improve their antioxidant status thereby improving animal health and welfare. Pomace consists of unfermentable sugars, tannins, anthocyanins, lycopene, and cellulose which have natural antioxidants, anti-inflammatory and antimicrobial properties. This review focused on the utilization of grape and tomato pomace as feedstuff for animals, the knowledge gap in the use of pomace in animal nutrition was also outlined. Supplementation of pomace generated from grape and tomato was evaluated on animal growth and reproductive performance, health, oxidative stress, animal products and gut health. In conclusion, incorporating agro-industrial byproducts into animal diet can be beneficial to farm animals by improving their health, welfare, performance as well as the environment, thereby leading to a more sustainable agricultural practice.

Keywords: animal feed, grape, pomace, tomato

1. Introduction

Pomace is the solid material which includes skins, pulp, stalk and seeds, that is generated from wine, juice or paste production from grape and tomato fruits (Nistor et al., 2014). Large quantities of pomace are generated yearly with severe economic and environmental impacts. The utilization of agro-industrial byproducts in animal production can lead to production of human-edible animal protein thereby contributing to sustainable animal production (van Hal et al., 2019; Salami et al., 2019) by reducing environmental pollution that can rise from these byproducts. Pomace disposal is time-consuming and costly due to its bulkiness and high water content, its utilization in animal diet is cheaper and environmentally friendly (Kalli et al., 2018). Agro-industrial byproducts can serve as functional additives in the animal industry due to their rich bioactive compounds which confer health benefits to animals; they also reduce feed costs and improve profitability (Galanakis, 2012; Kasapidou et al., 2015). The importance of agro-industrial byproducts in reducing reactive species, their ability to reduce methane emissions, as well as improving animal product quality, are factors to consider while using these byproducts in animal feed formulation (Salami et al., 2019). Grape pomace is a byproduct that could be used as an alternative feedstuff for livestock (Correddu et al., 2016).

Plant polyphenols can aid nutrient metabolism when consumed by animals (Vinyard et al., 2021), grape pomace is a rich source of condensed tannin while tomato pomace is high in lycopene which can favor animal production. These polyphenols exert beneficial effects on animal performance because of their antioxidant, antimicrobial, and anti-inflammatory properties, but their use is limited in monogastric animal nutrition due to the high level of lignin which cannot be easily digested and absorbed (Costa et al., 2022). Ruminant animals benefit from the high fiber content of pomace due to its fermentation by rumen microbes. The antimicrobial effect of polyphenols in pomace can be utilized in animal health while preventing residual effect of synthetic drugs thereby limiting the usage of synthetic drugs in animal production (Erinle & Adewole, 2022). The ability of ruminant animals to convert pomace with low nutritional value into valuable products improves the sustainable agricultural system (Flores et al., 2020).

Fresh pomace is not hazardous, but it can have negative effects on the environment when it is not properly managed, the deleterious effects include pollution of water bodies, soil oxygen depletion, it has phytotoxic effects on crops, attracts pests and flies which can transmit diseases (Beres et al., 2017; Dwyer et al., 2014). Depletion of oxygen occurs through the activity of phenol oxidase enzymes, which are responsible for the degradation of phenolics (Min et al., 2015). The alternative use of these byproducts can lead to sustainable agricultural practices (Chikwanha et al., 2019) which will benefit the environment by reducing agricultural footprint. In response to the consumers' demands for natural products, the meat and poultry industry is actively seeking natural products capable of increasing meat oxidative stability and extending product shelf life (Karre et al., 2013). The processing and usage of tomato and grape into products and byproducts is presented in Figure 1. Grape pomace supplementation caused significant increase in antioxidant activity in key organs such as the liver and kidney which are needed to maintenance good health in animals especially during weaning stress (Chedea et al., 2019). Tomato pomace supplementation could improve animal products and health due to its lycopene content (Czauderna et al., 2020). In addition, grape pomace supplemented in sheep diet increased total volatile fatty acids and decreased ruminal pH and ammonia nitrogen (Omer & Abdel-Magid, 2015). Ream et al. (2021) also reported grape pomace supplementation irrespective of method of preservation was effective in changing nitrogen excretion route from urine to feces which could improve environmental sustainability.

Supplementing tomato and grape pomace in animal diets could favor animal production by improving their growth and reproductive performance, maintenance of good oxidative status, reduction of inflammation and improvement of gut health as presented in Table 1. Therefore, this review focused on the use of grape and tomato pomace in animal production and the health benefits derived from pomace supplementation in animal diet.

2. Growth and Reproductive Performance

Growth and reproductive performance are important factors in animal production systems. These parameters are measured to detect improvement in animals' response to feed, environmental factors and different production systems. Gungor et al. (2024) reported that tomato pomace fermented with *Aspergillus niger* did not alter body weight, feed intake and feed conversion ratio of broiler chickens. Similarly, no effect on growth performance was observed when dietary tomato pomace was supplemented at 20, 30 g/kg (Faryabidoust et al., 2013) and 50 g/kg (Rezaeipour et al., 2012) to broiler chickens. This result could be attributed to the higher inclusion level of tomato pomace in the broiler diets, the high fiber and lignin content of tomato pomace could affect digestibility, absorption and utilization by the broiler chickens thereby reducing their productivity. However, Selim et al. (2013) observed an increase in body weight of broilers fed dietary supplementation of tomato puree at 5 and 10 g/kg. The variation in results could be attributed to the use of different parts of the byproduct and the lower inclusion level of the tomato byproducts. No significant change was observed in the feed intake, body weight gain, and feed conversion ratio of laying birds supplemented with 250-750 g/kg of grape seed extract (Hafeez et al., 2023). Sayago-Ayerdi et al. (2009) concluded that dietary supplementation of grape seed byproducts above 6% has a negative effect on feed intake in chicken. To corroborate this, several researchers reported negative or no effect of grape byproducts inclusion in animal diets on feed intake (Chamorro et al., 2013; Romero et al., 2021).

No significant effect of grape byproducts could be due to the concentrations of condensed tannins in the byproduct (Romero et al., 2022). Condensed tannin binds to proteins which reduce the digestibility of the protein, this can affect productive performance of the animals (Sun et al., 2018). Zadeh et al. (2023) reported that tomato pomace improved the reproductive performance of male broiler chickens. Fifty-eight (58) week old Ross male broiler breeders supplemented with 15% tomato pomace had increased semen volume when compared to 10% L-Arginine and control group, higher sperm concentration and increased sperm viability was also observed in tomato pomace supplemented group. Costa et al. (2022) supplemented grape pomace in pig's diet and reported that pigs fed 9% grape pomace showed an increase in average daily gain. The pre-treatments such as fermentation also affected the results by increasing the phenolic concentration of grape pomace. Certain studies discovered that adding 9% grape pomace boosted average daily gain without changing feed intake or feed conversion ratio. Other research, on the other hand, including those that used other grape by-product dosages or forms, did not find any appreciable impacts on feed intake, feed conversion or average daily gain. Li et al. (2024) found that implementing polyphenol-rich grape pomace into Angus bulls' diets can improve growth performance; this could be a result of the fermentation of the fiber content of the pomace which could have improved the proliferation of rumen microbes as well as production of short-chain fatty acids. Tomato pomace reduced body weight of lactating goats when supplemented at 60% of the diet and increased milk production at 40% supplementation (Mizael et al., 2022). Ya-qian et al. (2016) supplemented grape pomace in ram's diet and reported that rams fed grape pomace had increased testis weight, improved sperm quality and better testis antioxidant activity. Similarly, Selcuk et al. (2013) reported reduction in gamate abnormality rates and increase in spermatozoa concentration and motility of

breeder roosters supplemented with 5% dried tomato pulp. Grape seed tannin extract enhanced testis development and spermatogenesis by increasing testicular and epididymis weight in lambs. Supplementation of dried grape pomace at 1% level enhanced reproductive performance in rabbit bucks by increasing sperm motility and concentration (Derbali et al., 2024).

3. Oxidative Stress and Animal Health

Oxidative stress occurs when there is an imbalance in the detoxification system and the production, build-up of free radicals and reactive oxygen species in the body, majorly in the cells and tissues (Pizzino et al., 2017). Reactive oxygen species are generated as byproducts of metabolism which could play a variety of physiological factors such as destruction of DNA, lipids and cells (Pizzino et al., 2017). Environmental stressors can lead to oxidative stress by increasing the amount of free radical accumulation in the cells and tissues. These stressors include heavy metals, pollutants, and xenobiotics. Oxidative stress has been combated with numerous antioxidants such as polyphenols, vitamins, and flavonoids (Pizzino et al., 2017). Oxidative stress has been reported to be the cause and aid in the progression of numerous diseases such as cardiovascular diseases, metabolic diseases, atherosclerosis, and others (Taniyama & Griendling, 2003) by causing inflammation and reduction in animal's immunity. Apoptotic signaling is triggered when free radicals cause peroxidative damage to DNA, proteins, and lipids, reducing the activities of antioxidant enzymes and thereby disrupting homeostasis in antioxidants and prooxidants (Hajam et al., 2022).

Maintenance of animal health is the primary goal of animal production (Tlusty, 2020), poor or impairment in animal health leads to poor performance and productivity of the animals and sometimes the animals die of poor health (Tlusty, 2020). Grape pomace is a good source of antioxidant due to its strong antioxidant activity (Goni et.al., 2007), while grape seed oil has high levels of oleic and linoleic acids (Ageyeva et.al., 2021). Grape and tomato pomace have been reported to improve the health of animals. Kafantaris et al. (2016) conducted research on supplementing grape pomace to lambs for 55 days. He observed an increase in the concentrations of catalase and glutathione peroxidase enzymes, these enzymes scavenge free radicals in the body. Dietary supplementation of 10 g/kg of *Aspergillus niger-fermented* tomato pomace increased the serum glutathione peroxidase and superoxide dismutase levels in broilers compared with the control group (Gungor et al., 2024), similarly, Selim et al. (2013) observed tomato puree at 10 g/kg reduced the concentration of plasma malondialdehyde thereby reducing lipid peroxidation. Hosseini-Vashan et al. (2016) reported that dietary supplementation of tomato pomace increased serum high density lipoprotein and decreased serum total triglycerides and abdominal fat in broiler chickens. The lycopene present in tomato pomace also increased the high-density lipoprotein and decreased the low-density lipoprotein and very low-density lipoprotein levels in the serum of Japanese quail breeders at inclusion levels of up to 12% in the diet (Reda et al., 2022).

Blood malondialdehyde concentration significantly decreased in birds supplemented with grape seed extract (Hafeez et al., 2023). Kara et al. (2016) found that plasma malondialdehyde concentration decreased in laying hens. According to Brenes et al. (2010), the beneficial effects of pomace can be attributed to the polyphenols present in the pomace which serve as a good source of antioxidants. Incorporating pomace generated from grapes and tomatoes in an animal diet can provide beneficial antioxidant effects which improve the health and welfare of the animals.

4. Gut Health and Microbiome

Food animals need to have good intestinal health, it is important in food-producing animals because the gut is linked to the host animal's immunity (Kogut & Arsenault, 2016). Having a good gut microbiome can significantly improve animal performance and reduce the environmental impact of animal production (Rawal et al., 2024). The use of agro-industrial byproducts in animal nutrition could be a way to reduce the carbon footprint in food production systems. Pomace can reduce feeding expenses and improve the quality of animal products (Vastolo et al., 2022). Identifying alternative feeds that are appropriate for animal nutrition, like those from the agro-industrial sector, is necessary due to the ongoing rise in feed costs and the need to boost the sustainability of animal production (Correddu et al., 2023). In vitro trials showed that grape pomace used as a livestock feed ingredient could affect fermentation characteristics, decrease greenhouse gas production, and, most importantly, methane emissions (Vastolo et al., 2022). The bioactive compound in pomace could alter the proliferation of rumen microbes, thereby modifying the intestinal environments and the end products of gut fermentation (Vastolo et al., 2022). Gut manipulation has been used to improve the growth performance and feed efficiency in animals by feeding feed additives that improve the proliferation of beneficial microbes while reducing the population of harmful ones (Viveros et al., 2011). The relative abundance of Bifidobacteriaceae was increased in lambs supplemented with grape pomace; also, there was increase in the concentration of short chain fatty acids in the

rumen of the lambs (Cheng et al., 2023). Grape pomace can stimulate the gut microbiota to increase the proliferation of beneficial microbes which aid in producing short chain fatty acids as well as reduction in production of methanogens (Cheng et al., 2023). Tomato pomace improved the microbial diversity in pigs with the pomace supplemented group having a better alpha diversity (Goggans et al., 2022). Similarly, Firman et al. (2024) reported the probiotic effect of tomato seed extract by shaping the gut microbiota to benefit broiler chickens. However, Gungor et al. (2024) did not find any significant difference in the gut microflora of broiler chickens fed tomato pomace supplemented diet.

5. Animal Products

Lipid oxidation is one of the most important factors affecting meat quality; it affects the nutrient composition, odor, texture, taste, and flavor (Kanner, 2007). Lipid oxidation also poses health risks to consumers by producing some carcinogenic and mutagenic effects (Jimenez-Colmenero et al., 2001). Chikwanha et al. (2019) reported no significant difference in carcass pH and meat color 24 h postmortem of lambs fed grape pomace. They also observed significantly higher protein content in the meat of the pomace-supplemented groups which was attributed to the effect of tannin present in their diet. Grape pomace supplemented in laying hens diet improved their egg quality, the hens laid eggs with higher gallic acid content in the yolk (Herranz et al., 2024). Similarly, Hassan et al. (2024) reported lower fat deposition and higher antioxidant levels in the meat of rabbits fed tomato pomace supplemented diets. Rolinec et al. (2021) reported no significant difference in the fatty acid and protein concentration from the colostrum of dairy cows fed grape pomace. Reports showed that long-term supplementation of grape pomace in dairy cows' diets did not affect milk protein (Pauletto et al., 2020). Likewise, Nielsen and Hansen (2004) reported that feeding 4.5 g of grape pomace to dairy cows did not increase milk protein yield. Milk composition was not affected when Ianni et al. (2019) fed grape pomace to dairy cows.

The oxidative stability of cheese after 30 days of ripening was examined by Ianni et al. (2019) who fed grape pomace to cows, animals fed grape pomace had lower oxidation products thereby improving the cheese quality. Similar results were reported by Santos et al. (2014) with cow's milk quality improvement when fed grape pomace silage; Correddu et al. (2016) examined the oxidative stability of sheep milk fed grape seeds. There was an increase in linoleic acid concentration in dairy cow's milk fed 10% dried grape pomace (Ianni et al., 2019). This improved the fatty acid profile of the subsequent cheese made from the milk (Ianni et al., 2020).

Tomato puree supplementation in broiler diet did not affect the dressing percentage as well as heart, liver and gizzard (Selim et al., 2013; Gungor et al., 2014). Excessive abdominal fat in animal meat leads to economic loss to the producers (Cao et al., 2012), producing animals with lean meat is preferable by the consumers. Dietary inclusion of tomato pomace in broiler diet reduced abdominal fat when supplemented at 20-100 g/kg (Faryabidoust et al., 2013) and 30 g/kg (Hosseini-Vashan et al., 2016). Lipid metabolism may be regulated by the lycopene present in tomato pomace. Free radicals' formation in egg yolk was reduced when laying hens were fed grape seed (Kaya et al., 2014; Barbe et al., 2020). Tomato pomace reduced body weight of lactating goats when supplemented at 60% However, supplementing tomato pomace at 20% and 40% improved milk production and milk quality in lactating goats (Mizael et al., 2022). Tomato pomace increased egg weight and lycopene deposition into the egg yolk of Japanese breeder quails (Reda et al., 2022). Similarly, incorporating tomato pomace in pig's diet increased α-tocopherol in meat and liver as well as reduction of intramuscular fat content of the meat (Biondi et al., 2020). Similar result was observed by Peiretti et al. (2013) who reported an increase in polyunsaturated fatty acids and decrease in saturated fatty acid in the longissimus dorsi and perirenal fat in rabbit fed diet containing tomato pomace. Table 1 shows more information on the effects of supplementing grape and tomato byproducts in different species of animals.

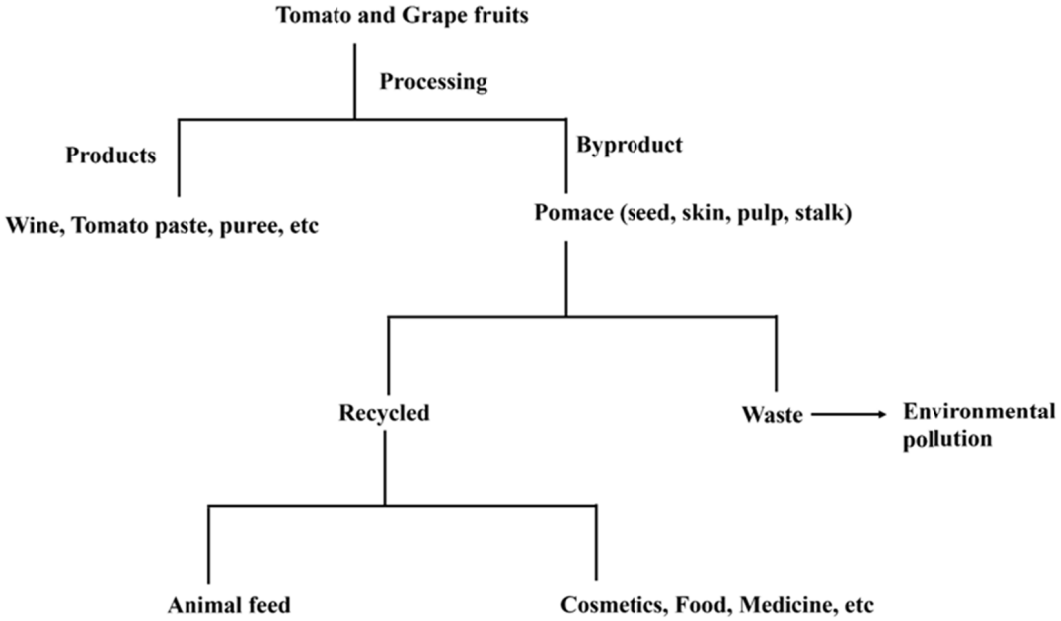

Figure 1. Flowchart of the processing and uses of grape and tomato pomace

Table 1. Summary of the use of grape and tomato pomace in animal production

Species	Byproduct	Parameters	Conclusion	References
Poultry	Grape	Egg quality	Egg yolks have phenolic compounds	Herranz et al. (2024)
Rabbit	Tomato	Meat quality	Increased meat quality with decrease in fat deposition	Hassan et al. (2024)
Lamb	Grape	Gut microbiota and short chain fatty acid	Increased proliferation of beneficial microbes and SCFA	Cheng et al. (2023)
Lamb	Tomato	Short chain fatty acid	Increased total short-chain fatty acid	Firrman (2024)
Poultry	Grape and Tomato	Growth performance and gut microbiota	Improved growth performance and increased proliferation of beneficial microbes	Viveros et al. (2011)
Lamb	Grape	Carcass pH and meat color Oxidative stress	No significant difference in carcass pH and meat color Increased concentration of catalase and glutathione peroxidase	Chikwanha et al. (2019) Kafantaris et al. (2016)
Cattle	Grape	Cheese quality Milk protein	Improved cheese quality No difference in milk protein yield	Ianni et al. (2019) Nielsen & Hansen (2004); Pauletto et al. (2020)
Tomato	Poultry	Dressing percentage	No effect on dressing percentage	Selim et al. (2013); Gungor et al., 2014
Poultry	Tomato	Reproductive performance	Increased semen volume, viability and sperm concentration	Romero et al. (2022); Sun et al. (2018)
Goat	Tomato	Milk production and quality	Improved milk production and quality	Mizael et al. (2022); Li et al. (2024)
Swine	Grape	Growth performance	Increase in average daily gain	Zadeh et al. (2023)
Cattle	Grape	Growth performance	Improved growth performance	Costa et al. (2022)
Poultry	Grape	Oxidative stress	Malondialdehyde concentration significantly decreased	Hafeez et al. (2023)
Poultry	Tomato	Lipid profile	Increased HDL, decreased triglycerides and abdominal fat	Reda et al. (2022)
Swine	Tomato	Meat quality	Reduced intramuscular fat and no effect on oxidative stability of meat	Biondi et al. (2020)
Swine	Tomato	Oxidative stress and inflammatory cytokines	Reduced antioxidant enzymes and inflammatory cytokines	Fouda et al. (2024)

6. Conclusion

The large tons of pomace generated annually from tomato processing and winemaking can greatly improve animal health and animal products. The polyphenols present in these agro-industrial byproducts help in scavenging free radicals and improving oxidative status of animals. From this review, the majority of the research with both tomato and grape pomace did not find a significant impact on the growth performance of the animals which could be due to the high fiber content and concentrated polyphenols in these byproducts. Grape and tomato pomace can serve as a means of improving animal health, animal products, and reproductive performance rather than improving growth

performance. More research should be done on the effect of grape and tomato pomace in reducing the occurrence of cardiovascular diseases in food animals. This will further increase the use of pomace in livestock production thereby leading to a more sustainable agricultural practice as well as improving human health.

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