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# Grape pomace (*Vitis vinifera* L. cv. Pinotage) supplementation in lamb diets: Effects on growth performance, carcass and meat quality

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ABSTRACT

This study investigated the effects of feeding graded levels of sun-dried red grape pomace (GP; 0, 5, 10, 15 and 20%) on growth, carcass and meat physico-chemical quality attributes of Dohne Merino lambs for 42 days. Dry matter intake increased quadratically with a critical value (i.e., optimum inclusion level) of 11.3% GP ($P \leq 0.05$). Diet exhibited similar quadratic responses for average daily gain, live, hot and cold carcass weights with optimum inclusion levels at 9.6, 9.7, 12, 2 and 12.1, respectively ($P \leq 0.05$). Overall, meat quality traits were not negatively affected by GP inclusion ($P > .05$). Gross profit was influenced by diet, with an optimum inclusion level at 12.2% (quadratic; $P \leq 0.05$). Overall, inclusion of 12.2% GP in lamb finishing diets at the expense of oat bran and wheat bran middlings improved lamb productivity, without compromising meat quality.

## 1. Introduction

Grape pomace (GP), a by-product of the wine industry has for a long time been undervalued and treated as a waste due to lack of alternative uses with economic benefits (García-Lomillo & González-Sanjosé, 2017). Pomace contributes the bulk of the solid fraction, approximately 25% of the pressed grapes, and mainly comprises skin (~51%), seeds (~47%) and stalks (~2%; Beres et al., 2017; Zhang, Hoadley, Patel, Lim, & Li, 2017). Although, GP is not hazardous, if not managed properly it has negative environmental effects including phytotoxic effects to crops, surface and ground water pollution, depletion of oxygen in soil and ground water by tannins and attraction of flies and pests that may spread diseases (Beres et al., 2017; Dwyer, Hosseinian, & Rod, 2014; Zhang et al., 2017). Depletion of oxygen occurs through the activity of phenol oxidases enzymes, which are responsible for degradation of phenolics (Min, Freeman, Kang, & Choi, 2015). The increased attention to sustainable agricultural practices demands finding alternative uses for this by-product.

It is estimated that only 3% of the global GP is used as animal feed (Brenes, Viveros, Chamorro, & Arija, 2016), with Australia, a major wine producing country using 13% as fodder (Zhang et al., 2017). The low usage of GP in livestock production is due to its high content of lignin and polymeric polyphenols, mainly proanthocyanidins which are associated with reduced digestibility through the inhibition of cellulolytic and proteolytic enzymes (Baumgärtel, Kluth, Epperlein, & Rodehutscord, 2007; Chikwanha, Raffrenato, Muchenje, Musarurwa, & Mapiye, 2018).

In pursuit of sustainable and economically viable ruminant livestock systems, many farmers worldwide are under increasing pressure to maximize the use of available agricultural byproduct-based diets for their livestock (Nkosi & Meeske, 2010) without compromising the performance and meat quality traits. Grape pomace has potential to be incorporated in ruminant diets because of its moderate to high protein content (9–15% dry matter; DM; Chikwanha et al., 2018; García-Lomillo & González-Sanjosé, 2017). Grape pomace is a waste product with low cost, giving it an added advantage over hay, which has to be purchased and often at a relatively higher cost (Moate et al., 2014). Zepf and Jin (2013) recomended that GP inclusion in ruminant diets should be, however, limited to not > 30% of the diet because of its high lignin and phenolic contents.

Despite the high phenolic content in GP, sun-drying (Pirmohammadi, Golgasemgarebagh, & Azari, 2007) or co-feeding (Waghorn, 2008) in combination with other feeds that have little or no phenolic compounds effectively reduces the levels of these compounds and improve feed intake, nitrogen and fiber digestibility (Kumar & D'Mello, 1995). Moderate levels of phenolic compounds, particularly

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tannins are recognized for their nutrient-binding properties, which improve nitrogen utilization of by-pass nitrogen by ruminants and subsequently growth (Perez-Maldonado & Norton, 1996). Furthermore, the bioactive compounds in GP could improve meat yield and quality (Guerra-Rivas, Gallardo, Mantecón, del Álamo-Sanza, & Manso, 2017; Manso, Gallardo, & Guerra-Rivas, 2016). Inclusion of GP in sheep diets also has the potential to reduce the cost of rations (Manso et al., 2016). Grape pomace produced in South Africa, especially, the local bred varieties have been relatively unexploited by the local meat industry as a source of animal feed, mostly owing to scant information on the benefits of GP as an ingredient in feedlot diets. Thus, the objective of the current study was to evaluate the effects of inclusion level of sun-dried red grape (*Vitis vinifera* L. cv. Pinotage) on growth, carcass and meat quality traits of feedlot-fed Dohne Merino lambs.

## 2. Materials and methods

The experiment was conducted between August and September 2017 at Welgevallen Experimental Farm (33.9427° S, 18.8664° E; Stellenbosch University, South Africa). The study protocol for care and use of animals used in the experiment was approved by the Stellenbosch University Animal Ethics Committee (SU-ACUD16-00143).

### 2.1. Preparation of diets

Fresh red GP (*Vitis vinifera* L. cv. Pinotage) was provided by Bellevue Wine Estate (33.879866° S, 18.763768° E) in Stellenbosch. Immediately after pressing, the GP was spread onto plastic canvas sheets under sunlight. The pomace was turned daily for 7 days to ensure moisture content was below 10% and milled to pass through a 4-mm sieve. Five pelleted (5-mm, at 80 °C) total-mixed diets were prepared by a registered commercial feed manufacturer: control (no GP) and four treatments with 5, 10, 15 and 20% GP meal, respectively (Table 1). All diets were formulated to be isoenergetic and iso-nitrogenous (National Research Council, 2007).

### 2.2. Diets, experimental design and animal management

Forty castrated Dohne Merino lambs averaging 32 ± 1.7 kg and 3–4 months old were purchased from a commercial feedlot in Hermon, South Africa. All the animals were treated for external (Inverject, FarmVet, South Africa) and internal (ByBoost Lamb and Kid + copper, Bayer (Pty) Ltd., South Africa) parasites, and vaccinated against enterotoxemia and Pasteurella (Enteroprotect P 100, DP, South Africa). Lambs were housed individually in slated floor pens (2 $m^2$). Lambs were assigned to dietary treatments (8 lambs /treatment) in a completely randomized design. Data collection commenced after a 14-day adaptation period and lasted for 42 days during which growth performance was monitored. Feed and clean fresh water were offered every morning ad libitum. Feed offered and corresponding orts were recorded daily to estimate voluntary DM intake (DMI) and representative samples collected weekly and stored at −20 °C for further analysis. Lambs were fasted for 16 h at the beginning of the trial and also before slaughter to determine the full-body weights of the animals. Weekly weights were taken before morning feeding to determine average daily gain (ADG) and feed efficiency (gain to feed ratio).

### 2.3. Chemical analyses

Dry matter (method 934.01), ash (method 942.05) and ether extract (EE; method 920.39) contents were determined according to the AOAC (2002) procedures. Total nitrogen content was analyzed using the Dumas method with a macro-Nitrogen analyzer (LECO® FP528, LECO Corporation, Miami, USA). Crude protein (CP) was calculated by multiplying the nitrogen content by a factor of 6.25. Starch was measured using a commercial assay (Total Starch Megazyme kit KTSTA, Megazyme International Ireland Ltd., Wicklow, Ireland), following the method for samples containing glucose and/or maltodextrins (Hall, 2009). Neutral detergent fiber (aNDFom) was determined using heat-stable alpha-amylase and addition of sodium sulfite (Mertens, 2002). Lignin was analyzed according to Goering and Soest (1970) as modified by Raffrenato and Van Amburgh (2011). Neutral detergent fiber and ADL were expressed exclusive of ash. Total tannin content was

**Table 1**
Feed ingredients and chemical composition of experimental diets (g/kg DM).

| Component | Inclusion of grape pomace (%) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | |
| Ingredients | | | | | | |
| Sun-dried Pinotage meal[1] | 0 | 50 | 100 | 150 | 200 | |
| Lucerne meal | 200 | 200 | 200 | 200 | 200 | |
| Soybean hulls | 37.6 | 49.2 | 48.2 | 38.6 | 5.6 | |
| Hominy chop (maize bran) | 50 | 50 | 50 | 0 | 0 | |
| Defatted maize germ | 150 | 150 | 150 | 150 | 130 | |
| Wheat bran middling's | 90.9 | 107 | 46.8 | 0 | 0 | |
| Oat bran | 50 | 3.1 | 0 | 0 | 0 | |
| Maize mea[a] | 281 | 275 | 292 | 327 | 325 | |
| Megalac[b] | 0 | 0 | 0 | 4.9 | 20.7 | |
| Molasses syrup | 40 | 40 | 40 | 40 | 40 | |
| Fish meal[c] | 0 | 0 | 0 | 0 | 3.81 | |
| Lupins | 13.3 | 0 | 5.97 | 17.3 | 0 | |
| Soybean meal[d] | 38.7 | 31.4 | 33.3 | 39.7 | 46.9 | |
| Limestone fine | 24.8 | 24.6 | 18.8 | 17.4 | 13.3 | |
| Salt fine | 8.2 | 4.2 | 4.4 | 4.6 | 4.2 | |
| Toxin binder (Mycosorb A) | 1 | 1 | 1 | 1 | 1 | |
| Mold inhibitor (Technigard) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | |
| Sal CURB® S liquid mix[e] | 5 | 5 | 0 | 0 | 0 | |
| Vitamin/Mineral Premix[f] | 7 | 7 | 7 | 7 | 7 | |
| Dust binder (Dustex) | 2 | 2 | 2 | 2 | 2 | |
| Chemical composition | | | | | | SEM[l] |
| DM (g/kg as-fed basis) | 880 | 879 | 878 | 880 | 881 | 0.55 |
| Organic matter | 910 | 917 | 928 | 922 | 924 | 1.14 |
| Crude protein | 173 | 179 | 179 | 175 | 174 | 1.55 |
| Ether extract | 37.1 | 44.8 | 49.8 | 55.0 | 63.4 | 1.11 |
| Starch | 258 | 263 | 261 | 263 | 259 | 7.82 |
| aNDFom[g] | 300 | 301 | 289 | 262 | 243 | 6.90 |
| ADFom[h] | 190 | 196 | 166 | 160 | 182 | 3.80 |
| Lignin (sa.)[i] | 31.4 | 47.3 | 61.0 | 70.7 | 77.7 | 3.71 |
| Metabolizable energy (MJ/ kg DM)[j] | 10.9 | 11.1 | 11.6 | 11.5 | 11.4 | 0.07 |
| Non-fiber carbohydrates[k] | 401 | 392 | 410 | 429 | 444 | 7.14 |
| Total tannins (g gallic acid equivalent/kg DM) | 0 | 27.4 | 34.7 | 48.7 | 59.4 | 2.20 |
| Proanthocyanidins (g cyanidin chloride equivalent/kg DM) | 0 | 7.9 | 12.3 | 17.8 | 25.7 | 0.20 |

[a] Chemical composition GP meal: 919 g/ kg DM; crude protein, carotenoids, 0.26 g/kg DM; ether extract, 89.3 g/kg DM; starch, 69.2 g/kg DM, aNDFom, 401 g/kg; total tannins, 143 g/kg DM; proanthocyanidins, 64.9 g/kg DM.
[b] Megalac: A high-energy rumen-protected fat supplement (Calcium Salt of Palm Fatty Acids).
[c] Fish meal containing 65% protein.
[d] Soybean meal: Soybean containing 47% protein.
[e] Sal CURB® S liquid mix: antimicrobial used to control *Salmonella* contamination.
[f] Vitamin/mineral premix (i.e., MW Sheep PX with Monesin 68,813). The composition of the vitamin/premix was not included because of a non-disclosure agreement with the feed manufacturer.
[g] aNDFom: neutral detergent fiber assayed with heat stable amylase and expressed exclusive of ash.
[h] ADFom: Acid detergent fiber expressed exclusive of ash.
[i] Lignin (sa): Lignin determined by solubilization of cellulose with sulfuric acid.
[j] Estimated according to CSIRO (2007).
[k] Non-fiber carbohydrates: Calculated as: 1000– (aNDFom g/kg + crude protein g/kg + ether extract g/kg + ash g/kg).
[l] SEM: Standard error of mean.