Animal Feed Science and Technology 169 (2011) 194–198

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Nutrient content and *in vitro* digestibility of Turkish grape pomaces

M. Basalan[a,*], T. Gungor[a], F.N. Owens[b], I. Yalcinkaya[a]

[a] *Department of Animal Nutrition, Faculty of Veterinary Medicine, Kirikkale University, Kirikkale, Turkey*
[b] *Pioneer Hi-Bred International, a DuPont Business, Johnston, IA, USA*

ARTICLE INFO

Article history:
Received 14 May 2009
Received in revised form 11 July 2011
Accepted 17 July 2011

Keywords:
Digestibility
Grape pomace
Nutrients
Rumen

ABSTRACT

During harvest of grapes for wine production in Turkey, a total of 28 fresh grape pomace samples from white and red wine grape varieties were collected from wine production facilities. Samples were classified by grape color and the pomace from red grapes was separated manually into stalk, skin plus pulp and seed fractions. Nutrient contents were determined for total samples and for fractions. Assays included dry matter (DM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF) and ash. To estimate ruminal digestion, *in vitro* disappearance of DM and NDF were determined using ruminal fluid collected at a local slaughterhouse. Color of grape altered ($P<0.05$) DM, CP, NDF and ADF content of the grape pomace. Although *in vitro* disappearance of DM and NDF at 48 h was similar for pomace from both white and red grapes, DM disappearance was higher at short incubation times for pomace from red grapes. Nutrient content generally differed among the fractions of pomace assayed, and *in vitro* disappearance of DM at 48 h was higher for skin plus pulp and for seed than for the stalk fraction of the pomace. Fresh grape pomace, particularly pomace from red grapes rich in skin and seed, should be a suitable feed for ruminants and to nonruminants with extensive cecal fermentation.

1. Introduction

Livestock producers continually search for economically feasible by-product feeds for livestock. Grape processing by-products, including seed, skin, pulp and stalk, commonly called grape pomace, have been studied by nutrition researchers as sources of dietary fiber and polyphenols in animal feeds (Baumgartel et al., 2007; Alipour and Rouzbehan, 2007; Spanghero et al., 2009). However, limited and localized availability of product, variable nutrient content and the presence of contaminants have limited use of grape by-products in the livestock and food industries (Spanghero et al., 2009).

Of the world's 66 million tonnes of grapes produced in 2007, about 0.40 was used for wine production (FAOSTAT, 2008). In Turkey, only 1.1% of the 3.9 million tonnes of grapes produced in 2007 was used for wine production (TUIK, 2007). Nevertheless, wineries produce a large amount of biodegradable waste during a short annual period which can pose a threat to the environment (Makris et al., 2007). Being rich in soluble fiber, grape pomace should have value as a component of ruminant diets, particularly in years when climatic conditions limit the availability of other feeds. The proportion of pomace produced ranges between 0.10 and 0.25 of total wet weight of the grapes (Laufenberg et al., 2003). Nutritional properties of grape by-products vary with method of wine production, type of grape (*i.e.* red *versus* white; Ruberto et al., 2008), and the

Abbreviations: ADF, acid detergent fiber; CP, crude protein; DM, dry matter; EE, ether extract; ME, metabolizable energy; NDF, neutral detergent fiber; NFC, non-fiber carbohydrates; OM, organic matter.

* Corresponding author at: Kirikkale University Faculty of Veterinary Medicine, Department of Animal Nutrition, Kampus, 71451 Yahsihan, Kirikkale, Turkey. Tel.: +90 318 3574242/3321; fax: +90 318 3573304.
E-mail addresses: basalan@kku.edu.tr, mehmetbasalan@yahoo.com (M. Basalan).

0377-8401/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.anifeedsci.2011.07.005

relative ratios of seeds, pulp, skin and stalk in the pomace (Baumgartel et al., 2007). Because these factors can alter chemical composition, they may also alter digestibility of grape pomace.

Although feeding grape pomace at the time of production has logistical advantages, nutrient losses during preservation as a feed has led to disposal of most pomace as organic fertilizer (Bustamante et al., 2008). However, large scale production and pooling from multiple sources, as well as separation of various pomace fractions, should permit pomace to be used more widely as a feed for ruminants. Our study was designed to determine the nutrient content of pomace from red and white grape species and from the stalk, skin plus pulp and seed fractions of pomace. Additionally, we determined the *in vitro* DM and NDF disappearance of grape pomace and its fractions.

2. Materials and methods

Fresh grape pomace samples were collected immediately after pressing the juice from wine producing companies located in the Kalecik, Akyurt and Kirikkale regions of Turkey. A total of 28 pomace samples were obtained from grape cultivars including the Kalecik Karasi cultivar, a source of a widely known red wine produced in this area, as well as Syrah, Tannat, Carignan, Cabernet Sauvignon, Merlot, Emir and local cultivars such as Hasandede. Approximately 1500 g of pomace was collected from each cultivar during the harvest season (*i.e.*, late summer and early autumn) and divided into two fractions. One half was held at −20 °C, with the other assayed for dry matter (DM; 934.01) and the dried material was ground and assayed for ash (942.05), crude protein (CP; 954.01) and ether extract (EE; 920.39) following AOAC (2005) procedures. NDF and ADF contents of each pomace sample were analyzed and expressed with residual ash (without either alpha-amylase or sodium sulphite in the ND) by methods of Van Soest et al. (1991). Non-fiber carbohydrates (NFC) were calculated by subtracting CP, EE and NDF from OM. ME values were calculated using the equation suggested by Robinson et al. (2004). The frozen portion of each red grape pomace sample thawed at +4 °C was manually separated into fractions visually identified as stalk, skin (and pulp) and seed. Because red grapes were more prevalent among the cultivars sampled, only red grapes were separated into these fractions, which were assayed as described above.

In vitro disappearance was estimated in an Ankom® Daisy Incubator (Ankom, Macedon, NY, USA) and rumen fluid was obtained from cattle slaughtered at a local slaughterhouse (Chaudhry, 2006). The farm of origin of the bulls that provided rumen fluid was located and the owner indicated that these bulls had been fed a diet consisting of 0.80 concentrate and 0.20 forage. The experiment was replicated thrice with each dried and ground (1 mm screen) sample being incubated with a 1:1 (v:v) mixture rumen fluid and McDougall buffer solution. Approximately 0.5 g of each dried sample ground through a 1 mm screen was placed in an Ankom® *in vitro* fermentation bag (40 μm pore size) and each bag was heat-sealed and bags were dried at 55 °C for 48 h prior to incubation. Half of the bags were extracted with neutral detergent solution (without alpha-amylase and sodium sulphite) prior to incubation, leaving only the NDF residues in the bags for digestion. Each sample was incubated in duplicate within the rotating jars containing the rumen fluid and McDougall buffer mixture for 0, 4, 12, or 48 h in each incubation jar. Bags were sequentially introduced into the jars so that all bags could be retrieved at the end of the incubation to decrease variability associated with bag washing. After incubation, bags were retrieved from the incubation jars and washed en masse under running warm tap water in a bucket until the wash water was colorless. Then, each bag was washed individually under running warm water. Sealed bags were extracted sequentially with ND and AD (without either alpha-amylase or sodium sulphite) to determine the amount of undigested NDF and ADF remaining in each bag.

The GLM procedure of SAS (1999) was used to test for differences in nutrient content among grape types and the red grape fractions, and for differences in disappearance of DM and NDF after 4, 24 and 48 h of incubations. Disappearance of grape types and fractions was corrected for loss of DM from bags that were washed but not incubated in jars. Disappearance also was measured due to washing alone. A difference at $P<0.05$ was considered significant and a difference of $0.05<P<0.10$ was interpreted as a tendency to a difference.

3. Results

All nutrient contents except EE differed ($P<0.05$) with grape color (Table 1). The DM, CP, NDF, ADF, and ash contents were higher ($P<0.01$) for pomace from red than from white grapes. Whether this represents a difference in composition of grapes harvested from varieties that differ in color, their maturity at harvest, the processing or separation procedures employed, or to other factors are not known. Water soluble DM, as well as disappearance of DM after 4 h of *in vitro* incubation was higher ($P<0.05$) for pomace from red than from white grapes, but differences associated with grape color had diminished by 12 h and had disappeared by 48 h. Disappearance at all incubation times was similar for NDF isolated from the pomace of red and white grapes, except at 4 h when NDF disappearance was higher for pomace from red than from white grapes.

As a fraction of initial dry weight, the stalk, skin plus pulp, and seed comprised an average of 332, 349, and 319 g/kg, respectively, of the pomace from white grapes and 207, 410 and 383 g/kg, respectively, of the pomace from red grapes. Compared with the stalk and the skin plus pulp fraction, the seed fraction contained more ($P<0.05$) EE, NDF, and ADF (Table 2). In addition, for CP and ash, the skin plus pulp was higher than stalk or seed fractions ($P<0.05$). Water soluble DM and DM disappearance was higher ($P<0.05$) for skin plus pulp than for other pomace fractions at all incubation times, and higher for seed than for stalk at 4 and 48 h of incubation. Water solubility and disappearance of NDF was less ($P<0.05$) for stalk than for other fractions from red grapes at 4 and 12 h of incubation.