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Influence of radiation processing of grapes on wine quality

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HIGHLIGHTS

- Grapes were subjected to radiation processing before wine making.
- Wines from irradiated grapes had higher antioxidant and phenolics compared to control.
- HPLC analysis confirmed improved extraction of phenolics due to radiation processing.
- Aroma profile and sensory quality of control and irradiated wines were similar.

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ABSTRACT

Grapes (Var. Shiraz and Cabernet) were subjected to radiation processing (up to 2 kGy) and wines were prepared and matured (4 months, 15 °C). The wines were analyzed for chromatic characteristics, total anthocyanin (TA), phenolic (TP) and total antioxidant (TAC) content. Aroma of wines was analyzed by GC/MS and sensory analysis was carried out using descriptive analysis. TA, TP and TAC were 77, 31 and 37 percent higher for irradiated (1500 Gy) Cabernet wines, while irradiated Shiraz wines demonstrated 47, 18 and 19 percent higher TA, TP and TAC, respectively. HPLC-DAD analysis revealed that radiation processing of grapes resulted in increased extraction of phenolic constituents in wine with no qualitative changes. No major radiation induced changes were observed in aroma constituents of wine. Sensory analysis revealed that 1500 Gy irradiated samples had higher fruity and berry notes. Thus, radiation processing of grapes resulted in wines with improved organoleptic and antioxidant properties.

1. Introduction

Grape wine is the most popular fruit wine consumed around the world with a history of over 5000 years (Zeng et al., 2008). The aroma of a wine is one of the major factors that determine its quality and plays an important role in consumer preference (Jiang et al., 2013). The aroma of a wine is a result of a combination of chemical compounds that influence its organoleptic characteristics. Over 800 volatile compounds in wines have been identified. Several classes of compounds, mainly alcohols, esters, aldehydes, acids, monoterpenes and other minor components are present in the volatile aroma of wine. The formation of these volatile compounds depends on various factors such as vineyard environmental factors (soil and climate), process of grape and juice production (grape de-stemming, crushing and pressing technology), and the fermentation and ageing procedure (Sagratini et al., 2012). Another important group of substances influencing various organoleptic properties such as color, astringency and bitterness of wine are the phenolic compounds (Garrido and Borges, 2013). Phenolic compounds also have antioxidant properties and are responsible for health promoting properties of wine (Donsi et al., 2010).

As a consequence of the large influence of phenolic compounds on the quality of red wine, a great effort has been devoted in recent years to develop different techniques to enhance their extraction during the wine making process. Various techniques proposed to enhance extraction of these compounds are increasing fermentation temperature, extending maceration time, heating grape berries for a short time, freezing grape berries before fermentation, and pulsed electric fields (Bautista-Ortí et al., 2007; Sacchi et al., 2005). However, using these techniques could lead to wines with poor and unstable color characteristics (Puértolas et al., 2010).

Treatment of food and agricultural commodities by γ-irradiation is a physical process involving direct exposure of food products to electromagnetic γ-rays or electron beam for improvement in safety and shelf life (Lacroix and Ouattara, 2000). Use of radiation processing has been successfully demonstrated to increase the phenolic content in several products such as soybeans (Variyar,

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Limaye and Sharma 2004). Ananthakumar et al. (2006) demonstrated that radiation processing leads to breakdown of aroma glycosides in nutmeg leading to enhanced volatile content and improved sensory quality. However, studies on radiation processing of wine are very few and rare. Gamma irradiation of Cabernet Sauvignon red wine increased the chemical color age of wine with no perceivable differences in sensory quality with doses up to 2400 Gy (Caldwell and Spayd, 1989). It has also been reported previously that irradiation is a suitable method for improving the taste quality of the rice and maize wines (Chang, 2003, 2004). However, to the best of our knowledge, no report exists on quality evaluation of wine prepared with radiation processed grapes.

Studies on effect of radiation processing of grapes on subsequent wine quality especially assume importance due to the fact that more fruits are subjected to radiation processing for phytosanitary applications. Currently, most widely used method for phytosanitary treatment of grapes is methyl bromide fumigation. However, since methyl bromide is an environmental pollutant which causes depletion of ozone layer, it is in process of being phased out (US EPA, 2012). Radiation processing could be a suitable alternative for methyl bromide fumigation. Radiation processed (up to 800 Gy) Sugraone and Crimson seedless grapes had acceptable quality till 3 weeks of storage (Kim et al., 2014). Radiation processing was also demonstrated to improve the shelf life of 2 cultivars of Syrian grapes, Helwani and Baladi (Al-Bachir, 1999). Use of SO_2 treatment in combination with gamma radiation was found to be effective for controlling postharvest *Botrytis cinerea* rot in several varieties of cold-stored SO_2 treated table grapes (De Kock and Holz, 1991). The upper limit for treatment of fresh produce in the United States is 1000 Gy (21 CFR 179.26) but higher for other countries. In view of above it is likely that grapes subjected to radiation processing for phytosanitary applications might be used for wine making. Therefore, the aim of the present study was to investigate the effect of radiation processing of grape berries on the antioxidant and aroma quality of wines. Shiraz and Cabernet Sauvignon varieties, widely used for wine making are chosen for present study.

2. Material and methods

2.1. Materials

Red grapes (*Vitis vinifera*) of Shiraz and Cabernet sauvignon variety were procured from a grower in Narayangaon, Maharashtra. Grapes were manually harvested at optimum ripening stage (22° Brix) and transported to the lab within 12 h after harvest.

2.2. Radiation processing of grapes

Grape were packed (500 g) in perforated polyethylene packages and were then subjected to radiation (500, 1000, 1500 and 2000 Gy) processing in a Food Package Irradiator (AEC, Canada) having a source strength of 60 kCi and a dose rate of 45 kGy h^{-1}. Temperature during radiation processing was 25 ± 2 °C. Irradiator was calibrated using a Fricke dosimeter before the start of experiment and dose uniformity ratio (D_{max}/D_{min}) was found to be 1.2. Uncertainty of the doses was found to be within the limit of ± 1%. Post irradiation the berries were immediately processed for wine making.

2.3. Wine preparation

Wine preparation was carried out essentially as per procedure detailed earlier (Jacobson, 2006). In brief, berries (2000 g) were crushed and resultant musts were adjusted to 24° Brix by adding the required amount of glucose. Musts were then added with 50 ppm potassium metabisulfite ($K_2S_2O_5$). After 2 h musts were inoculated with 1% overnight grown yeast (*Saccharomyces cerevisiae*) (strain SC-101, CFTRI, India) inoculum and fermentation was carried out at 25 ± 1 °C. During fermentation flasks were shaken and the cap was punched twice a day. After completion of fermentation (200 h) seeds and skins were separated from wine by pressing and wines were raked twice. The wines were then stored in amber colored bottles at 15 °C for a period of 4 months of maturation. Three independent samples were prepared for each treatment.

Table 1
Sensory attributes with their description and corresponding reference standards used for descriptive sensory analysis of wine.

S. no.	Sensory attributes	Description	Reference standards
	Appearance		
1	Red	Assessed by tilting glass at 45°. Low anchor (Light) High anchor (Dark)	
2	Clarity	Transparent or cloudy. Assessed by tilting glass at 45°. Low anchor (cloudy) High anchor (clear)	
	Aroma		
3	Fruity	Grape like	Grape Juice
4	Berry	Cranberry, blackberry	Cranberry Juice
5	Spice	Clove like	Cloves
6	Floral	Flowery, rose like	Rose petals
7	Honey	Honey, caramel	Honey
8	Woody	Pencil shavings	Pencil shavings
9	Smoky	Cigarette smoke like	Burnt cigarette
10	Vinegar	Acetic, sour	10 times diluted vinegar
	Taste		
11	Astringency	Dry, puckering	800 mg/L aqueous alum solution
12	Bitter		800 mg/L anhydrous caffeine dissolved in water
13	Sourness	Sour, acidic	2 g/L tartaric acid dissolved in water
14	Sweetness		15 g/L (D)-fructose dissolved in water
15	Warmth	Warm to hot	150 mL/L vodka in water
16	Body	Viscosity, mouthfeel. Low anchor (Thin) High anchor (Thick)	7 g/L pectin dissolved in water