This work was aimed to investigate the bioactive compounds and antioxidant activity of wines from different currant cultivars. Currant fruits, black currant (Ribesnigrum Moravia CV.), red currant (R. rubrumLosan CV.) and white currant (R. rubrum Primus CV.), were collected from a fruit nursery in Modrice, Czech Republic in the year July 2015 and frozen at -18°C until used for further experiment. Black currant was crushed and the whole fruit was directly used for wine making, whereas only the juice of the red and white currents was used for wine making. Total soluble solid (TSS), titratable acidity (TA), and pH of the juice were determined. The TSS was adjusted to 20°Brix, and the TA of the juice was adjusted to 7.5 g/L. Then, the juice was transferred to fermentation bottles. After 12 days-fermentation, chemical composition (TSS, TA, pH, total SO₂, bioactive compounds (total phenolic compounds (TPC) and total monomeric anthocyanin (TMA)) and antioxidant activity (DPPH and FRAP assays) were determined. The results showed that the black currant wine had the highest total soluble solid (15.80 Brix) followed by white currant wine (12.03°Brix) and red currant wine (8.40°Brix), respectively. The white currant wine exhibited the highest titratable acidity (9.32 g anhydrous citric acid/mL), whereas there was no significant difference in pH found for all currant wines (P>0.05). The optimum TSS and TA of white currant contributed to the highest alcohol content in white wine (11.6 %). However, the black currant wine provided the highest TPC, TMA and antioxidant activity (DPPH and FRAP assays). The wine with the higher TPC exhibited the higher antioxidant activity, indicating that the TPC is responsible for the antioxidant activity of the wine.

**Keywords:** Ribesspp., black currant, red currant, white currant, anthocyanin

**INTRODUCTION**

Currant (Ribes spp.) has a short harvest season and it has fragile fruit that is prone to spoilage during storage and transportation. It can be consumed fresh or processed to various products, such as juice, jam, dried fruit, etc. There are many works reported that the currant exhibits numerous biological activities, for instance, anti-inflammatory, anticaner, antioxidant activities, etc. (Konić-Ristić et al., 2011; Lipińska, Klewicka, & Sękja, 2014). The main bioactive compounds in red and black currents are anthocyanins, flavonols, procyandinids, phenolic acids, ascorbic acid and flavonoids (Bakowska-Barczak & Kolodziejecyz, 2011; Zdunić, Šavkin, Pljevljakšić, & Djordjević, 2016), whereas proanthocyanidins, hydroxybenzoic acid, queretin and hydroxycinnamic acid derivatives such as caffeic acid and ferulic acid and phenolic acids are the main bioactive compounds in white currant (Määttä, Klewicz, & Sójka, 2014; Rajakangas, Misikangas, Pa’iva’rinta, & M., 2008; Tian et al., 2017; Vuorinen, Määttä, & Törönen, 2000).

Fermentation has known to extend the shelf-life and could enhance nutritional, organoleptic as well as functional qualities of food (Terefe, 2016). Fruit wine, made from a variety of fruits in which are very rich in fermentable sugars with additional specific flavors and aromas, is becoming popular among the world health concern consumers. Wine production from currants increasingly interests people particularly in European countries as a result of its health benefits perception from the fruit itself and the compounds generated from the fermentation process.

Currant biochemical reactions occurring during fermentation have been reported to both reduce and enhance the antioxidant activity depending on various factors (Wang et al., 2015; Wen, Yan, & Chen, 2013; Xiao et al., 2015).Various works have reported on the bioactive compounds and biological activities of grape wines from different grape cultivars and their by-products (Bajić et al., 2015; Durak et al., 1999; Radovanović, Đekić, & Radovanović, 2011). In addition, recent research of currant wine brewing has intensively investigated on optimizing the fermentation process. However, report on chemical composition,
bioactive compounds and antioxidant activity of the wine produced from different currant cultivar is limited. This work, therefore, was aimed to investigate of chemical properties (total soluble solid (TSS), titratable acidity (TA), pH, total sulfur dioxide and alcohol content), bioactive compounds (total phenolic compounds (TPC) and anthocyanin (TMA) and antioxidant activity (DPPH and FRAP assays) of different currant wines from different currant cultivars to provide some information for currant wine processing.

MATERIALS AND METHODS

Reagents
All reagents were analytical grade. Folin-Ciocalteu’s phenol reagent, gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), trolox (±)-6-Hydroxy-2, 5, 7, 8 - tetramethylchromane-2-carboxylic acid and ascorbic acid were purchased from Sigma-Aldrich Corp. (USA).

Currant fruits
Currant fruits, black currant (Ribes nigrum Moravia CV.), red currant (R. rubrum Losan CV.) and white currant (R. rubrum Primus CV.), were collected from a fruit nursery in Modrice, Czech Republic in the year July 2015 and frozen at -18 °C until used for further experiment.

Microorganisms
Commercial wine yeast, Saccharomyces cerevisiae was purchased from a commercial wine yeast merchandize in Lednice, Czech Republic.

Fruit Juice Preparation
Black currant was crushed by hands and the whole fruit underwent directly for wine making, whereas only the juice of the red and white currents was used for wine making. Titratable acidity (TA), pH and total soluble solid (TSS) of the juice were determined. Then, TSS was adjusted to 20 Brix by sugar and TA of the juice was adjusted to 7.5 g/L by water and the juices (2.0 kg) were transferred to fermentation bottles with air lock assembled.

Fruit Wine Fermentation
Potassium metabisulfite was added into the fermentation bottles in order to obtain 30 mg active sulfur dioxide /kg juice and left overnight at ambient temperature. The wine yeast (0.4 g/L) was inoculated into the fermenters. The fermenters were left at ambient temperature for 12 days. Sampling was conducted at the end of fermentation and the samples were stored at the temperature of −18 °C for titratable acidity (TA), pH, total soluble solid (TSS), free sulfur dioxide, alcohol content, bioactive compounds (total phenolic content, anthocyanin), and antioxidant activity (DPPH and FRAP assays) determination. Residue sulfur dioxide was determined at 12-day fermentation.

Chemical properties determination
Titratable acidity (TA) was determined according to AOAC (2005) method and expressed as g anhydrous citric acid (ACA) per mL sample. Total soluble solid (TSS) and pH were measured by a refractometer and pH meter, respectively.

Total sulfur dioxide determination
The total sulfur dioxide was determined by Ripper titration method (Iland, 2000) with some modifications. Briefly, the sample (50 mL), 16 % sulfuric acid (10 mL) and starch solution (5 mL) were pipetted to an Erlenmeyer flask and titrated with 0.02 M iodine solution until blue color was obtained (30 sec. stable). The total sulfur dioxide was calculated and expressed as milligram free sulfur dioxide per liter of the sample.

Alcohol content determination
The alcoholic content in the wine was determined by distillation and relative specific gravity measurement by hydrometer (Amerine & Ough, 1974). Briefly, a known volume of sample (150 mL) with an antifoaming agent were filled into the distillation chamber and distilled in a distillation unit to obtain the distillate with the same volume of the original sample. The specific gravity of the distillate and the temperature were determined. Then, the specific gravity was converted to % alcohol by volume using the table of specific gravity of aqueous ethanol solutions as a function of % alcohol (v/v).

Bioactive Compounds Determination
Total phenol content (TPC)
The TPC was determined as described by Singleton and Rossi (Singleton & Rossi, 1965) with some modifications. Gallic acid (10, 20, 40, 60, 80 and 100 µg/mL) was used as a standard. Five milliliters of 10 % v/v Folin-Ciocalteu’s reagent and 10 mL of 7.5 % sodium carbonate were added to one milliliter of the diluted sample or standard and vortexed. Then, the solution was left at room temperature for 60 min before the absorbance was determined at 765 nm. The total phenolic content of the sample was expressed as gram gallic acid equivalent (GAE) per liter. All samples were analyzed in triplicates.

Total monomeric anthocyanin (TMA)
The TMA was determined using pH-differential method (AOAC, 2005). Equal portions of the extract were mixed with pH 1.0 buffer or pH 4.5 buffer, then the absorbance of both solutions was determined at the wavelength of 520 and 700 nm, respectively, using distilled water as a blank. The TMA was calculated and expressed as milligram malvidin-3-glucoside (M-3-G) equivalent per liter.

Antioxidant activity determination
Free radical scavenging activity (DPPH) assay
The antioxidant activity of all sample was evaluated through the free radical scavenging effect on DPPH radical (Brand-Williams et al., 1995). Trolox (0, 200, 400, 600, 800 and 1000 µM) was used as a standard. The sample or the standard (50 µL) and 60 mM DPPH solution (2,000 µL) were transferred to a test tube and thoroughly mixed and stored in the dark for 10 min. The absorbance was determined at the wavelength of 517 nm using methanol as a blank. DPPH scavenging activity was expressed as mmotrolox equivalent (TE) per liter.

Ferric reducing antioxidant power (FRAP) assay
The FRAP assay was conducted according to Benzie and Strain (Benzie & Strain, 1996) with some modifications. Potassium hexacyanoferrate solution (1 % w/v; 2.5 mL) and phosphate buffer (pH 6.6) were added into tubes that contained one milliliter of the sample or the standard solution. The tubes were then placed in a water bath at 50 °C for 30 min. Then, trichloroacetic acid (10 % w/v; 0.5 mL) was added and the absorbance was determined at 700 nm. FRAP reducing power was expressed as mmoltrolox (TE) per liter.

Statistical analysis
All tests was conducted in triplicates for verification of the results and subjected to analysis of variance (ANOVA). A mean composition was carried out by Duncan’s Multiple Range Tests. Statistical significance was set at p-value ≤ 0.05. All data analyses were performed using SPSS package (V16).

RESULTS AND DISCUSSION

Black currant wine had the higher total soluble solid (15.80 °Brix) followed by white currant (12.03 °Brix) and red currant (8.40 °Brix), respectively, as shown in Table 1. White currant wine exhibited the highest titratable acidity (9.32 g anhydrous citric acid/ mL), whereas there was no significant difference in pH was found for all currant wines (P>0.05). Alcohol content in red (9.76 %) and black currant (9.58 %) wines were similar, however these were higher than that of the which currant wine (11.6 %). This higher alcoholic content in white currant wine may due to the influence of the preferable acidity and the TSS of the white currant juice. In addition, black and red currants
generally contain anthocyanin in which undetectable in white currant and contains higher flavonoids compared to the white currant. These compounds have been known to have antimicrobial activity, therefore, may affect the starter culture activity resulting in the lower alcohol content in the wine (Mattila, Hellström, Karhu, Pihlava, & Veteläinen, 2016). Total sulfur dioxide present in wine has to be limited to a certain amount in order to comply with the legislation (< 150-200 mg/L) and not to provide undesirable tastes and aromas to the wine and adverse health effect to the human health. From the results it was found that total sulfur dioxide in all currant wines was lower than the maximum permitted level (Table 1).

Bioactive compounds and antioxidant activity

The TPC and TMA in the wine from different currant cultivars are shown in Table 2. The black currant wine (1457.54 mg GAE/L) was higher than that of the white (1077.92 mg GAE/L) and the red currant (501.18 mg GAE/L) wines respectively. These results are consistent with Vuorinen et al. (2000) who reported that white currant wine contained the highest TPC (520-1820 mg GAE/L) compared to that of the red currant wine (335-1250 mg GAE/L). However, the white currant wine in this work had the higher TPC compared to the previous report one (250-270 mg GAE/L) which may due to a variety of factors, including the variety of the currant, fermentation conditions, etc. (Yang, Zheng, Laaksonen, Tahvonen, & Kallio, 2013).

CONCLUSION

In conclusion, the black currant wine exhibited higher bioactive compounds and antioxidant activity compared to the white and red currant wine, respectively. In addition, the compound responsible for the antioxidant activity in the black currant wine was mainly phenolic compound.

ACKNOWLEDGEMENTS: Author would like to thank Mae Fah Luang University and Mendel University in Brno for financial support. Author would like to gratefully acknowledge Assoc. Prof. Dr. Josef Balík, Head of department, Ms. Jana Kulichová and her colleagues for their kind assistant during doing this work at the Department of Post-Harvest Technology, Faculty of Horticultural, Mendel University in Brno.

REFERENCES


Maatta, K., Kamal-Aldin, A., & Torronen, R. (2004). Phenolic compounds in berries of black, red, green, and white currants (*Ribes* sp.) Antioxidants & Redox Signaling, 3(6), 981-993


Received: 04. 02. 2018. Accepted: 02. 03. 2018.