Mitteilungen Klosterneuburg 53 (2003): 159-165

Polyphenols and Antioxidative Capacity in Hungarian Tokaj Wines

Martin S. Pour Nikfardjam[1,3], Gyula László[2] and Helmut Dietrich[3]

[1] Present address: Research Institute for Viticulture and Oenology
H-Pécs, Pázmány Péter u. 4
E-mail: martinpn@axelero.hu

[2] László Pincészet
H-3907 Tállya, Dobogó utca 47

[3] Forschungsanstalt Geisenheim, Fachgebiet Weinanalytik
D-65366 Geisenheim, Rüdesheimer Str. 28
E-mail: h.dietrich@fa-gm.de

Polyphenols and antioxidative capacity in Hungarian Tokaj wines. *20 wines from Tokaj (Hungary) were analysed for their polyphenolic composition, total polyphenol content and antioxidative capacity. The base wines for Tokaji Aszú production show high polyphenol contents ranging from 327 to 714 mg/l (mean: 455 mg/l) and an antioxidative capacity between 1.9 and 3.6 mmol/l (mean: 2.7 mmol/l). Wines belonging to the Forditás and Szamorodni group have even higher contents of polyphenols due to winemaking technique (long skin contact). Their values range from 681 to 1033 mg/l (mean: 807 mg/l) and from 3.4 to 5.5 mmol/l (mean: 4.6 mmol/l) for the antioxidative capacity. The highest values could be found in Tokaji Aszú wines. Here the winemaking technique (addition of botrytised berries to alcoholic base wine, second fermentation) leads to an excellent extraction of these compounds leading to total polyphenol contents between 609 and 1403 mg/l (mean: 890 mg/l) and an antioxidative capacity between 1.1 and 7.4 mmol/l (mean: 3.6 mmol/l). These values therefore are comparable to red wines and moderate consumption of these wines could contribute to the health benefits of wine drinking.*
Keywords: Tokaj, Aszú, wine, polyphenols, antioxidative capacity, TEAC

Polyphenole und antioxidative Kapazität in ungarischen Tokajer Weinen. *20 Weine aus Tokaj (Ungarn) wurden hinsichtlich ihrer Polyphenolzusammensetzung, ihres Gesamtphenolgehaltes und ihrer antioxidativen Kapazität untersucht. Die Grundweine für die Tokaji Aszú Herstellung weisen hohe Gesamtphenolgehalte zwischen 327 und 714 mg/l (Mittel: 455 mg/l) und eine antioxidative Kapazität zwischen 1,9 und 3,6 mmol/l (Mittel: 2,7 mmol/) auf. Die zur Forditás- und Szamorodni-Gruppe gehörenden Weine haben sogar noch höhere Werte aufgrund der Herstellungstechnologie (lange Maischestandzeit). Ihre Werte liegen zwischen 681 und 1033 mg/l (Mittel: 807 mg/l) und zwischen 3,4 und 5,5 mmol/l (Mittel: 4,6 mmol/l) für die antioxidative Kapazität. Die höchsten Werte konnten jedoch in Tokajer Aszú Weinen gefunden werden. Hier führt die Herstellungstechnologie (Zugabe von botrytisierten Trauben zu einem alkoholischen Grundwein, zweite Gärung) zu einer hervorragenden Extraktion dieser Komponenten. Die Werte liegen daher zwischen 609 und 1403 mg/l (Mittel: 890 mg/l) für den Gesamtphenolgehalt und zwischen 1,1 und 7,4 mmol/l (Mittel: 3,6 mmol/l) für die antioxidative Kapazität. Diese Werte sind mit Rotweinen durchaus vergleichbar und moderater Konsum dieser Weine könnte daher sehr wohl zu den gesundheitlichen Effekten des Weinkonsums beitragen.*
Schlagwörter: Tokaj, Aszú, Polyphenole, Antioxidantien, TEAC

La teneur des vins Tokaj hongrois en polyphénols et leur capacité antioxydante. *20 vins de Tokaj (Hongrie) ont fait l'objet d'analyses portant sur leur composition polyphénolique, leur teneur en polyphénols totaux et leur capacité antioxydante. Les vins de base pour la production de Tokaji Aszú présentent des teneurs importantes en polyphénols totaux entre 327 et 714 mg/l (moyenne: 455 mg/l) et une capacité antioxydante entre 1,9 et 3,6 mmol/l (moyenne:*

2,7 mmol/l). Les vins du groupe Forditás et Szamorodni présentent même des teneurs encore plus élevées, dues à la technologie de vinification (longue période de macération). Leurs teneurs se situent entre 681 et 1033 mg/l (moyenne: 807 mg/l) et entre 3,4 et 5,5 mmol/l (moyenne: 4,6 mmol/l) pour la capacité antioxydante. Les teneurs les plus élevées ont cependant été trouvées dans les vins Tokaji Aszú. Ici, la technologie de vinification (addition de raisins botrytisés au vin de base alcoolique, deuxième fermentation) entraîne une excellente extraction de ces composants. Les valeurs se situent donc entre 609 et 1403 mg/l (moyenne: 890 mg/l) pour les polyphénols totaux et entre 1,1 et 7,4 mmol/l (moyenne: 3,6 mmol/l) pour la capacité antioxydante. Ces teneurs sont tout à fait comparables à celles des vins rouges, et une consommation modérée de ces vins pourrait donc avoir des effets bénéfiques sur la santé.
Mots clés : Tokaj, Aszú, polyphénols, antioxydants, TEAC

Tokaj Aszú is certainly one of the most prestigeous wines in Hungary. For centuries the "wine of kings, king of wines" has been highly acclaimed by emperors, writers and composers. During these hundreds of years the production technique has hardly changed and the unique taste and flavour of the Tokaj Aszú has been literally a constant institution in the Hungarian wine world. After long disputes with international legislation organisations "Tokaj" now is a trade name and can only be used for wines produced in the Hungarian "Tokaj-Hegyalja" region. This region is situated in the north-east of Hungary in the district of "Borsod-Abaúj-Zemplén". "Hegyalja" meaning "at the mountain slope" explains the location of the vineyards in this region at the bottom of the Zemplén and Eperjés-Tokaj mountains. The region is triangularly shaped, covers about 275 km^2, and the rivers Bodrog and Thisza run through it providing the necessary humidity for Botrytis cinerea growth. Botrytis is one of the key factors for the unique taste and flavour of Tokaj Aszú.

But since Tokaj wines are usually produced with a high amount of botrytized berries, the impact of the Botrytis enzyme laccase will ultimately have a detrimental oxidative effect on the polyphenols in Aszú berries. Polyphenols are so-called secondary plant components and are synthetised via the amino acid pathway via shikimate. They are used by plants as messenger compounds, defense chemicals against fungus and viral diseases, as UV protection, radical catchers, and antioxidants.

Many epidemiological studies have indicated the decreasing risk of coronary heart disease through moderate wine consumption (Renaud et al., 1992; Renaud et al., 1998). Moderate wine consumption has also been related to preventing cancer, Alzheimer's disease and dementia (Dorozynski, 1997; Orgogozo et al., 1997; Renaud et al., 1992). The polyphenols in red and white wine have been linked to these effects. They have been made responsible for the inhibition of the oxidation of human low-density lipoprotein (LDL), the inhibition of the dioxygenase activity of lipoxygenase and platelet aggregation, and they are said to have anti-inflammatory effects (Frankel et al., 1993; Pace-Asciak et al., 1995; Teissedre et al., 1996). Especially the antioxidative effect of polyphenols has been the main research focus in the recent years. Many methods have been developed to analyse the antioxidative effect or capacity of wines and polyphenols. One of the most commonly used is the so-called TEAC test (Trolox Equivalent Antioxidative Capacity) where the antioxidative effect of the wine is directly compared to a water-soluble vitamin E derivative.

Some authors have lined out that vinification techniques have a great influence on the final polyphenolic composition of must and wine (Pour Nikfardjam et al., 1998; Ritter, 1994; Spanos et al., 1990; Vrhovsek et al., 1996). Important factors also include variety, climate, fungus pressure in the vineyard, and soil composition. To date barely no information about polyphenols and their antioxidative capacity in Tokaj Aszú wines has been published. The only study on polyphenols in Tokaj wines that is available was published by Drawert et al. (1976). Beside this general lack of information it is not clear, which impact the relatively high amounts of botrytized Aszú berries as well as the traditionally oxidative vinification techniques in Tokaj will have on the final polyphenolic composition of these wines. This is even more important since polyphenols and their antioxidative capacity have been linked to the health benefits of moderate wine consumption. From that point of view it was interesting to investigate the polyphenol content of Tokaj Aszú wines and their antioxidative capacity and assess their potential contribution to providing antioxidants.

Materials and Methods

Wines

A total of 20 wines from the Hungarian "Tokaj-Hegyalja" region (vintages 1981 to 1999) were analyzed. The wines were from different sources, representing a large spectrum of Tokaj wines. 'Furmint' and 'Hárslevelü' were chosen since they represent about 98 % of the cultivars used in Tokaj. Both cultivars belong to *Vitis vinifera* convar. *pontica* and make up about 70 and 28 %, respectively. 'Traminer' was chosen as an experimental variety since it belongs to *Vitis vinifera* convar. *occidentalis* and is currently not used for Tokaj Aszú production.

HPLC Analysis

Analysis was performed using the method published by RECHNER et al. (1998). All samples were filtered through Brown Rim L filters (Schleicher & Schuell Brown, Spartan 30/0.45 RC, 0.45 µm) and directly injected into a HPLC (Merck-Hitachi L-6200A) equipped with an auto sampler (Merck-Hitachi AS-2000) and a diode array detector (Merck LaChrom L-7210). Chromatograms were recorded at 280 nm. The system was equipped with an RP-column (Fluofix® 120E, NEOS Company Ltd., Kobe/Japan; 250 x 4.6 mm, 5 µm particle size), with a pre-column of the same material maintained at 20 °C with a column oven (Biorad). The injection volume was 20 µl.

Total polyphenols

Total polyphenols were estimated using the Folin-Ciocalteu method (RITTER, 1994). The results were calculated as (+)-catechin.

Antioxidative Capacity (TEAC-Test)

The antioxidative capacity was estimated using the method of MILLER et al. (1993) in a slightly modified form (POUR NIKFARDJAM, 2001).

Results and Discussion

Base wines

'Furmint' and 'Hárslevelü' represent the most abundant cultivars in Tokaj wines. 'Traminer' was chosen as an experimental variety for making base wine. Their polyphenol contents analyzed by HPLC ranged from 31 to 111mg/l (Table 1). The most important polyphenols in these wines were caftaric acid and catechin, as expected. Caftaric acid, besides tyrosol, is often the predominant polyphenol in white wines (POUR NIKFARDJAM, 2001; RITTER, 1994). The relatively high concentrations of flavan-3-ols, such as catechin, epicatechin, and procyanidin B_2, are probably due to long skin contact during vinification. They are mainly located in skins and seeds and thus long skin contact ultimately increases the extraction of these compounds out of the grape seeds and skins.

Despite the oxidative handling and vinification methods in Tokaj the wines did not show high concentrations in tyrosol. This compound is usually formed in musts under oxidative conditions from the amino acid tyrosine. Thus, it is an indicator for oxidative procedures in the winery (POUR NIKFARDJAM, 2001; RITTER, 1994). But tyrosol could not be found in any of the wines analyzed.

The relatively high concentrations of catechin in 'Furmint' and 'Traminer' are good indicators for the long skin maceration time during vinification of Tokaj Aszú. Skin maceration is often extended to 24 to 36 hours in Tokaj to obtain a high sugar free extract and maximum flavor extraction from the skins. Therefore, the increasing alcohol content during this period, besides cellulytic and pectolytic enzymes, supports the extraction of polyphenols from grape skin and seeds where they are usually located.

Compared to the values published by DRAWERT et al. (1976), the 'Furmint' wines analyzed in our studies showed much lower concentrations of syringic, caffeic, sinapic, and ferulic acid and quercetin (Table 4). In fact, most of them could not be detected in the wines analyzed. Gallic acid, protocatechic acid and catechin concentrations were similar to those published in literature. Seasonal as well as enological influences could be the explanation for these differences. As polyphenols are synthetised via the amino acid pathway a shift in nitrogen supply could already influence amino acid production and therefore also polyphenol synthesis. Other factors such as water and UV stress have also been shown to alter amino acid biosynthesis.

Szamorodni

Szamorodni wine is normally produced in dry or cold years with only slight yields of Aszú berries, when pikking of the Aszú berries does not pay for it. Sound and

Table 1:
Polyphenols and antioxidative capacity in Hungarian Tokaj wines (base wines); values given in mg/l; (n.d. = not detected)

	Furmint 1998	Furmint 1999	Harslevelü 1996	Harslevelü 1998	Harslevelü 1999	Traminer 1999
Gallic acid	4.5	1.9	7.5	1.7	0.3	1.1
Protocatechic acid	8.8	2.9	5.9	2.6	2.8	2.9
Tyrosol	n.d.	n.d.	n.d.	n.d.	1.1	n.d.
3-OH-Benzoic acid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Caftaric acid	23.1	20.3	9.3	16.9	11.8	17.2
Catechin	32.4	5.7	11.5	3.8	n.d.	32.0
GRP	n.d.	n.d.	3.4	n.d.	1.4	7.0
Procyanidin B2	5.8	1.0	n.d.	0.7	n.d.	2.4
p-CGT	6.7	8.6	5.6	7.9	5.0	7.7
Syringic acid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Caffeic acid	n.d.	n.d.	5.3	n.d.	3.7	3.4
Epicatechin	11.7	2.1	1.7	1.8	n.d.	9.1
Coutaric acid	10.7	21.8	n.d.	17.1	n.d.	9.4
Sinapic acid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fertaric acid	1.9	1.7	1.2	1.6	1.4	1.6
p-Coumaric acid	5.5	1.4	12.0	7.4	3.5	5.0
Ferulic acid	n.d.	n.d.	0.9	n.d.	n.d.	0.7
Ellagic acid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Quercetin-3-galactosid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Quercetin-3-rutinosid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Quercetin-3-glucosid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Quercetin	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Sum (mg/l)	111.1	67.4	64.3	61.5	31.0	99.5
Folin (mg/l)	383	401	714	344	327	559
TEAC (mmol/l)	2.2	2.5	3.5	2.2	1.9	3.6

botrytized berries are processed together. These wines show high contents of p-coutaric acid, caftaric acid, and catechin, but compared to the 'Furmint' base wines their concentration is significantly lower (Table 2). The higher amount of shriveled berries in Szamorodni compared to the base wines could lead to these lower values evoked by the oxidizing effect of the Botrytis enzyme laccase. Laccase reduces the polyphenols in the Aszú berries through its oxidative effect and thus Szamorodni shows lower concentrations on monomeric phenols.

Forditás

Forditás is obtained from the pomace of the Aszú after the pressing and extraction of the fermented Aszú berries. The pomace is combined with a high quality base wine with high sugar free extract and high alcohol content. While the Forditás wines do not show any high values for monomeric polyphenols in general, they have very high polyphenol contents as measured by Folin-Ciocalteu method (Table 2). These high values are probably due to polymeric polyphenols, which are extracted from the Aszú pomace by the alcohol of the

Table 2:
Polyphenols and antioxidative capacity in Hungarian Tokaj wines (Forditás, Szamorodni); values given in mg/l (n.d. = not detected)

	Forditás	Forditás	Szamorodni	
	1996	1999	1998	1998
Gallic acid	5.5	9.5	9.2	9.0
Protocatechic acid	3.7	1.8	2.2	2.7
Tyrosol	n.d.	n.d.	n.d.	n.d.
3-OH-Benzoic acid	n.d.	n.d.	n.d.	n.d.
Caftaric acid	n.d.	8.5	19.6	13.0
Catechin	n.d.	27.4	13.2	8.4
GRP	n.d.	0.5	n.d.	n.d.
Procyanidin B2	n.d.	1.1	2.2	1.8
p-CGT	3.3	16.5	11.6	9.6
Syringic acid	n.d.	n.d.	n.d.	n.d.
Caffeic acid	n.d.	n.d.	n.d.	n.d.
Epicatechin	n.d.	9.2	4.7	4.4
Coutaric acid	3.5	12.6	29.3	11.2
Sinapic acid	n.d.	n.d.	n.d.	n.d.
Fertaric acid	0.3	n.d.	n.d.	n.d.
p-Coumaric acid	5.0	2.4	6.3	3.3
Ferulic acid	n.d.	n.d.	n.d.	n.d.
Ellagic acid	n.d.	n.d.	n.d.	n.d.
Quercetin-3-galactosid	n.d.	n.d.	n.d.	n.d.
Quercetin-3-rutinosid	n.d.	n.d.	n.d.	n.d.
Quercetin-3-glucosid	n.d.	n.d.	n.d.	n.d.
Quercetin	n.d.	n.d.	n.d.	n.d.
Sum (mg/l)	21.3	89.5	98.3	63.4
Folin (mg/l)	681	1033	730	787
TEAC (mmol/l)	3.4	5.5	4.9	4.7

base wine. Monomeric phenols have already been extracted during Aszú making and, thus, are inevitably lost and can usually not be found in Forditás wines. Their high polymeric polyphenol content is also a good indicator for their strong astringent taste and slight bitterness. According to VIDAL et al. (2002) higher polymeric polyphenolic structures ultimately increase bitterness and astringency. Polymeric polyphenols also lead to relatively high antioxidative capacities (TEAC values). One of the wines reached 5.5mmol/l, which is significantly higher than, for example, German white wines with a mean of 0.7 mmol/l (POUR NIKFARDJAM, 2001).

Table 4:
Phenolic compounds (mg/l) in Tokaj wines as analyzed by DRAWERT et al. (1976)
(n.a. = not analysed; 5p. = 5 puttonyos; 6p. = 6 puttonyos)

	Furmint	Aszú 5p.	Aszú 6p.
	1973	1963	1973
Gallic acid	1 - 5	10 - 20	5 - 10
Protocatechuic acid	1 - 5	1 - 5	1 - 5
3-Hydroxy benzoic acid	n.a.	n.a.	n.a.
Caftaric acid	n.a.	n.a.	n.a.
Catechin	20	1 - 5	5 - 10
GRP	n.a.	n.a.	n.a.
Procyanidin B_2	n.a.	n.a.	n.a.
p-CGT	n.a.	n.a.	n.a.
Syringic acid	1 - 5	0.1 - 1.0	0.1 - 1.0
Caffeic acid	1 - 5	0.1 - 1.0	0.1 - 1.0
Epicatechin	10 - 20	1 - 5	5 - 10
Coutaric acid	n.a.	n.a.	n.a.
Sinapic acid	0.1 - 1.0	0.1 - 1.0	1 - 5
Fertaric acid	n.a.	n.a.	n.a.
p-Coumaric acid	n.a.	n.a.	n.a.
Ferulic acid	5 - 10	1 - 5	1 - 5
Ellagic acid	n.a.	n.a.	n.a.
Quercetin	0.1 - 1.0	0.1 - 1.0	0.1 - 1.0

Aszú wines

The Aszú wines (5 to 6 puttony) showed very high contents on p-coutaric acid and caftaric acid (Table 3). The high p-coutaric acid concentration could be due to the reaction of hydroxycinnamic acids with tartaric acid in the pulp under the influence of water evaporation and hence concentration of the berry content under the influence of Botrytis. In opposition to DRAWERT et al. (1976) we could not detect syringic, sinapinic, ferulic acid and quercetin. For gallic acid we found slightly lower, for catechin much higher concentrations than DRAWERT et al. (1976) (Table 4).
The polyphenol content as measured by Folin-Ciocal-

Table 3:
Polyphenols and antioxidative capacity in Hungarian Tokaj wines (Aszú, Eszencia); values given in mg/l (n.d. = not detected; 5p. = 5 puttonyos; 6p. = 6 puttonyos)

	Aszú 5p. 1993	Aszú 5p. 1993	Aszú 5p. 1994	Aszú 5p. 1995	Aszú 5p. 1996	Aszú 5p. 1998	Aszú 5p. 1998	Aszú 5p. 1999	Aszú 6p. 1981	Eszencia 1999
Gallic acid	4.2	6.0	2.9	3.9	7.0	13.9	7.2	6.9	0.9	2.8
Protocatechuic acid	6.4	5.5	6.4	6.1	5.4	4.8	3.0	3.4	7.2	7.1
Tyrosol	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
3-OH-Benzoic acid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Caftaric acid	2.1	5.8	1.1	5.7	n.d.	10.3	36.2	36.4	n.d.	10.9
Catechin	n.d.	n.d.	2.7	n.d.	7.7	20.8	17.2	23.4	n.d.	n.d.
GRP	n.d.	1.1	n.d.	n.d.	n.d.	0.3	n.d.	n.d.	n.d.	4.1
Procyanidin B2	n.d.	n.d.	n.d.	n.d.	n.d.	4.4	3.2	n.d.	n.d.	n.d.
p-CGT	2.9	4.9	4.0	3.9	3.3	9.1	26.2	18.3	n.d.	10.9
Syringic acid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Caffeic acid	n.d.	n.d.	n.d.	n.d.	1.0	n.d.	n.d.	n.d.	n.d.	n.d.
Epicatechin	n.d.	0.8	n.d.	1.8	n.d.	8.4	7.9	9.3	n.d.	n.d.
Coutaric acid	3.9	18.5	2.1	7.0	n.d.	11.2	47.6	47.1	1.6	25.6
Sinapic acid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fertaric acid	0.7	n.d.	1.1	0.8	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
p-Coumaric acid	3.3	6.8	5.7	6.2	4.5	4.4	3.8	3.9	2.6	6.8
Ferulic acid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ellagic acid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Quercetin-3-galactosid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Quercetin-3-rutinosid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Quercetin-3-glucosid	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Quercetin	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Sum (mg/l)	23.5	49.4	26.0	35.4	28.9	87.6	152.3	148.7	12.3	68.2
Folin (mg/l)	690	717	621	744	710	1403	1168	1085	609	1154
TEAC (mmol/l)	2.0	3.0	2.4	3.1	2.5	7.4	6.1	5.9	1.1	2.8

teu method was very high. It ranged from 609 to 1403 mg/l. Therefore, their antioxidative capacity was also relatively high. Values up to 7.4 mmol/l were reached. These high values are probably due to polymeric phenols and Maillard products, which contribute to the Folin and TEAC values. Therefore, these wines already reach values, which are normally only known for red wine. Generally, red wine shows TEAC values between 3.0 and 30 mmol/l depending on cultivar and wine style (Simonetti et al., 1996; Pour Nikfardjam, 2001).

While most Aszú wines were from vintages between 1993 and 1999, the Aszú 6 puttonyos represented the 1981 vintage. Because of its age it showed lower amounts of polyphenols in general and also lower antioxidative capacity due to the much longer aging period in which more oxidative degeneration could have occurred. This could be one of the reasons why we found much lower concentrations on polyphenols in this wine than Drawert et al. (1976). In fact, only 12.3 mg/l of polyphenols could be analyzed by HPLC in

this wine, probably due to extensive oxidative losses during vinification as already discussed above.

Eszencia

In Eszencia again p-coutaric acid was the dominant phenolic compound (Table 3). This could be due to the fact that Eszencia is produced by leaving the Aszú berries in a tank where they are being pressed by their own weight. This leads to a very sweet, highly acidic juice, which basically already represents the Eszencia. Since most of the polyphenols in the pulp are hydroxycinnamic acids and the main acid in the pulp is often tartaric acid, the high concentration of both compounds in the pulp could easily lead to a formation of p-coutaric acid, an ester composed of p-coumaric and tartaric acid. The high Folin value of 1154 mg/l is an indicator for the high content of polymeric polyphenols in this wine. Again, the high amounts of botrytized berries during production could have led to the formation of polymeric polyphenols formed under the oxidative influence of Botrytis. These polymers generally have higher molar antioxidative properties and therefore strongly contribute to the TEAC value.

Conclusions

Generally, Tokaj wines contain relatively high concentrations of polyphenols and higher antioxidative capacities than German wines for example. On the one hand Botrytis infection leads to the oxidative degeneration of (monomeric) polyphenols in Aszú berries. On the other hand the traditionally oxidative handling and long skin maceration time of these wines during vinification leads to the oxidative formation of polymeric components and to the extraction of these compounds out of the skins. This ultimately increases the Folin value and the antioxidative capacity of these wines, which can reach values so far known only for red wine. Therefore, moderate consumption of these wines could contribute to a significant intake of antioxidants. Further studies are necessary to investigate the metabolism and bioavailability of these antioxidants from Tokaj Aszú in humans.

References

Dorozynski, A. 1997: Wine may prevent dementia. British Med. J. 314: 997.

Drawert, F., Leupold, G. und Lessing, V. 1976: Gaschromatographische Bestimmung der Inhaltsstoffe von Gärungsgetränken. VI. Quantitative gaschromatographische Bestimmung von Neutralstoffen (Kohlenhydraten) und phenolischen Verbindungen in Tokajer Weinen. Z. Lebensm. Unters. Forsch. 162: 407-414

Frankel, E.N., Kanner, J., German, J.B., Parks, E. and Kinsella, J.E. 1993: Inhibition of oxidation of human low-density lipoprotein by phenolic substances in red wine. The Lancet 341: 454-457

Miller, N.J., Rice-Evans, C. and Davis, M.J. 1993: A novel method for measuring antioxidant capacity and its application to monitoring the antioxidant status in premature neonates. Clinical Sci. 84: 407-412

Orgogozo, J.M., Dartigues, J.F., Lafont, S., Letenneur, L., Commenges, D., Salamon, R., Renaud, S. and Breteler, M.B. 1997: Wine consumption and dementia in the elderly : a prospective community study in the Bordeaux area. Revue Neurologique (Paris) 153(3): 185-192

Pace-Asciak, C.R., Hahn, S., Diamandis, E.P., Soleas, G. and Goldberg, D.M. 1995: The red wine phenolics trans-resveratrol and quercetin block human platelet aggregation and eicosanoid synthesis : Implications for protection against coronary heart disease. Clin. Chim. Acta 235(2): 207-219

Pour Nikfardjam, M.S. (2001): Polyphenole in Weissweinen und Traubensäften und ihre Veränderung im Verlauf der Herstellung. - Giessen: Diss. Justus-Liebig-Univ., 2001

Rechner, A., Patz, C.D. und Dietrich, H. 1998: Polyphenolanalytik von Fruchtsäften und Weinen mittels HPLC/UV/ECD an einer fluorierten RP-Phase. Dt. Lebensm. Rundsch. 94: 363-365

Renaud, S. and de Lorgeril, M. 1992: Wine, alcohol, platelets, and the French paradox for coronary heart disease. The Lancet 339: 1523-1526

Renaud, S., Gueguen, R., Schenker, J. and d'Houtaud, A. 1998: Alcohol and mortality in middle-aged men from Eastern France. Epidemiology 9(2): 184-188

Ritter, G. (1994): Die Bedeutung der phenolischen Saft- und Weininhaltsstoffe während der Verarbeitung von Äpfeln, Speierling und weißen Trauben : Der Einfluß moderner Verfahrenstechnologie auf die Qualität des Endproduktes. - Gießen: Diss. Justus-Liebig-Univ., 1994

Spanos, G.A. and Wrolstad, R.E. 1990: Influence of processing and storage on the phenolic composition of Thompson seedless grape juice. J. Agric. Food Chem. 38: 1572-1579

Vrhovsek, U., Wendelin, S. and Eder, R. 1996: Effects of various vinification techniques on the concentration of cis- and trans-resveratrol and resveratrol glucoside isomers in wine. Amer. J. Enol. Vitic. 48: 214-219

Simonetti, P., Brusamolino, A., Pellegrini, N., Gardana, C., Pietta, P.G. and Testolin, G. (1996): Polyphenol content and total antioxidant potential of selected Italian wines. In: Bull. Liaison, Polyphenols Communications '96, pp. 465-466. Univ. Bordeaux, 1996

Teissedre, P.L., Walzem, R.L., Waterhouse, A.L., German, B.J. et Frankel, E.N. 1996: Composés phénoliques du raisin, du vin et santé. Revue des Oenol. (79): 7-14

Vidal, S., Francis, L., Courcoux, P., Cheynier, V. and Waters, E.J. (2002): Mouth-feel properties of proanthocyanidins : influence of proanthocyanidin structure and of interaction with wine components. Presented at the XXI Int. Conference on Polyphenols. - Marrakech/Morocco, September 2002

Received April 23, 2003