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POLYPHENOL CONTENT AND ANTIOXIDANT PROPERTIES OF BEER

A. LUGASI*

National Institute of Food Hygiene and Nutrition, "Fodor József" National Center of Public Health, H-1097 Budapest, Gyáli út 3/a. Hungary

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Total polyphenol content and in vitro antioxidant properties were investigated in five lager and three dark beers. The average concentration of total polyphenols in lager and dark beers was 376 and 473 mg l^{-1}, respectively. All samples exhibited strong hydrogen-donating property and reducing power in a concentration-dependent manner. Beers also showed copper(II)-chelating ability and antioxidant property in Randox TAS measurement. The differences of polyphenol content and antioxidant characteristics between lager and dark beers were statistically not different. Antioxidant properties were dependent on the total polyphenol content of beers. The concentration of polyphenols and antioxidant properties except for chelating ability of beers measured in the same in vitro test system was very similar to those characteristics of white wine, while the extent of chelating ability of beers showed similarity to that of red wines. Studies evaluating the relative benefits of wine versus beer versus spirits suggest that moderate consumption of any alcoholic beverage is associated with lower rates of cardiovascular disease. Although beers have antioxidant capacity like white wines with having half the alcoholic content of wines, beers should be good sources of antioxidant polyphenols, and moderate consumption as a part of a well-balanced diet cannot be criticised either medically or socially and may have a beneficial effect on reducing oxidative disorders.

Keywords: beer, wine, polyphenol content, antioxidant properties

Antioxidants can be of endogenous and exogenous origin and contribute to the complex and integrated biological antioxidant defence system, which normally protects cells from the injurious effects of oxidation. This is achieved by directly scavenging reactive O and N centered free radical species by metabolising peroxides to non-radical products and by chelating metal ions to prevent the induction or activation of oxidizing enzymes (DIPLOCK et al., 1998).

Recently it has become clear that certain polyphenolic compounds of the phenylpropanid biosynthetic pathway in plants have considerable antioxidant ability as reviewed by BRAVO (1998); HOLLMAN and KATAN (1999), DUTHIE and co-workers (2000). There are no deficiency states for these phytochemicals and therefore, even though dietary intakes may exceed 1 g per day (FORMICA & REGELSON, 1995), they have been generally regarded as non-nutritive.

Plants produce thousands of phenolic compounds as secondary metabolites. Polyphenols are effective antioxidants in a wide range of chemical oxidation systems,

* Phone: (36-1)4766475; fax: (36-1)2151545; e-mail: h4550tot@ella.hu

being capable, for example, of scavenging peroxyl, alkyl peroxyl, superoxide, hydroxyl radicals, nitric oxide and peroxynitrite in aqueous and organic environments (for review see DUTHIE & CROZIER, 2000). In a similar manner to vitamin E, this activity is essential due to the ease with which an H atom from an aromatic hydroxyl (OH) group can be donated to a free radical and the ability of an aromatic compound to support an unpaired electron due to delocalisation around the π-electron system. The stoichiometry and kinetics of these reactions are influenced by a number of structural determinants including the number and position of OH groups, the type and position of glycosilation and the degree of steric hinderance at the site of H abstraction (RATTY & DAS, 1988; BORS et al., 1990). In addition, many polyphenols can bind transitional metal ion catalysts such as Cu and Fe to prevent generation of initiating free radicals through Fenton reaction (THOMPSON et al., 1976; AFANAS'EV et al., 1989). Certain polyphenols may have antioxidant ability in biological systems as they decrease markers of oxidative damage to lipids, proteins and DNA in primary cell cultures as well as in immortalized and transformed cells (MELZIG et al., 1997; ZHANG et al., 1997; DUTHIE & DOBSON, 1999).

Among alcoholic beverages antioxidant activity of wine is intensively investigated as a potential preventing effect of coronary heart disease, and there is a significant body of evidence that the moderate consumption of wine during meals, typical of Mediterranean diet, is beneficial to health. However, studies evaluating the relative benefits of wine versus beer versus spirits suggest that moderate consumption of *any* alcoholic beverage is associated with lower rates of cardiovascular disease (DENKE, 2000). From nutritional standpoint, beer contains more protein and B vitamin than wine. The antioxidant content of beer is equivalent to that of white wine, but lower than that of red ones, and the specific antioxidants are different because the barley and hops used in the production of beer contain polyphenols different from those in the grapes used in wine-making (DENKE, 2000). Beer is supposed to be a good source of polyphenols because significant amount of phenolics are present in barley, malt and hops. Depending on the variety, barley has 1.2–1.5 g kg^{-1} polyphenols (MADIGAN et al., 1994), while fresh hops contain about 700 mg kg^{-1} quercetin and about 550 mg kg^{-1} kaempferol in the form of glycosides (HERRMAN, 1988).

LIÉGEOIS and co-workers (2000) observed significant antioxidant activity in wort, malt and hops. In their system hop appeared as an oxidation inhibitor 30 times more efficient than the tested malt. Special polyphenols, namely prenylated flavonoids found in hops and beer were tested in different systems for their antioxidant properties. MIRANDA and co-workers (2000) reported that xanthohumol, the major prenylchalcone of the female inflorescence (cops) of the hop plant (*Humulus lupulus* L.) and beer showed high antioxidant activity in inhibition of LDL oxidation, higher than α-tocopherol, but lower than the flavonol quercetin. Chalcones with prenyl- and geranyl-groups were also effective inhibitors of microsomal lipid peroxidation induced by Fe^{2+}/ascorbate, and to a lesser extent on the lipid peroxidation induced by Fe^{3+}-ADP/NADPH and by tert-butyl hydroperoxide (RODRIGUEZ et al., 2001).

YILMAZER and co-workers (2001) reported that xanthohumol have a potential cancer-chemopreventive activity. In a human study GHISELLI and co-workers (2000) observed that beer was able to induce significant increase in plasma antioxidant capacity, while phenolic (caffeic, sinapic, syringic, vanillic) acids measured in plasma tended to increase after beer intake. GASBARRINI and co-workers (1998) studied the relationship between chronic moderate beer consumption and oxidative stress in rats. Plasma lipoproteins from the group consuming beer (30% w/w in the diet) showed a greater propensity to resist lipid peroxidation than lipoproteins of non-treated animals. Authors concluded that moderate consumption of beer in a well-balanced diet did not appear to cause oxidative stress in rats; moreover, probably through its minor components, beer could attenuate the oxidative action of ethanol itself.

Since limited data are available on total polyphenol content and antioxidant properties of commercial beers, the objectives of our present work were i) to investigate the total polyphenol content of some selected lager and dark beer, ii) to study the in vitro antioxidant characteristics of those products, iii) to establish the relationships between the concentration of polyphenolic compounds and the antioxidant properties, and iv) to compare the characteristics of beer to those of white and red wines on the bases of our earlier observations (LUGASI et al, 1999; LUGASI, 2000; 2001). For the characterization of antioxidant properties of beers and wines the same in vitro measuring system has been used thus the results of beers and wines are easy to compare.

1. Materials and methods

1.1. Chemicals

1,1-Diphenyl-2-picrylhydrazyl (DPPH), catechin and tetramethylmurexide (TMM) were obtained from Sigma Chemical Co. (MO, USA). Hexamine was purchased from Merck (Germany). Randox kit was obtained from Randox Laboratories Ltd. (Ardmore, UK). All other chemicals and reagents were of analytical grade from Chemolab (Hungary).

1.2. Beverages

Three bottles of five different lager and three dark commercial beers were purchased from local stores. Name, origin and other characteristics of beer samples can be seen in Table 1. Samples of three bottles were combined, homogenised and degassed with intensive stirring during 3 h at room temperature. Homogenised portions of samples were stored at –18 °C for less than 4 months until analysed.

1.3. Determination of total polyphenol content

The total polyphenol content present in beers was determined spectrophotometrically using Folin-Denis reagent (A.O.A.C., 1990). Samples were diluted with distilled water and filtered where appropriate. Folin-Denis reagent (0.5 ml) was added to 1 ml diluted

sample and the content of the tube was mixed thoroughly. After 3 min, 1 ml of saturated Na_2CO_3 was added. The mixture was completed to 10 ml with distilled water. It was allowed to stand for 30 min at room temperature. The absorbance was determined at 760 nm. Total polyphenol content was calculated using catechin as standard.

Table 1. Characteristics of beers

No.	Name of beers	Quality	Alcohol content (v/w%)	Country of origin
1.	Chimay	lager	7.0	Belgium
2.	Tuborg[a]	lager	5.0	Denmark
3.	Amstel	lager	5.0	Hungary (licensed)
4.	Spaten	lager	5.2	Germany
5.	Gold Fassl	lager	5.3	Austria
6.	Leffe	dark	6.5	Belgium
7.	DAB	dark	5.0	Germany
8.	Borsodi	dark	6.7	Hungary

[a] According to the leaflet attached to the product, beer contains antioxidant added (E224, potassium metabisulfite)

1.4. Hydrogen-donating ability

Hydrogen-donating ability of beers was determined in the presence of 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical as described by BLOIS (1958) and modified by HATANO and co-workers (1988). Diluted samples in different concentrations and portions of distilled water were added to a methanolic solution of DPPH (1 mM, 1 ml). The total volume was 5 ml. The mixture was shaken and left to stand at room temperature for 30 min. The absorbance of the resulting solution was measured spectrophotometrically at 517 nm. Hydrogen-donating ability of beers was calculated by the discolouration of DPPH expressed as percentage of the control, which contained 5% ethanol in distilled water instead of the beverages. Hydrogen-donating ability is expressed as I_{50}, the amount of the sample that is needed for 50% discolouration of DPPH. Lower value shows higher activity.

1.5. Reducing power

The reducing power of beers was determined according to the method of OYAIZU (1986). Diluted sample (1 ml) was mixed with phosphate buffer (2.5 ml, 0.2 M, pH 6.6) and 1% potassium ferricyanide (2.5 ml); the mixture was incubated at 50 °C for 20 min. Trichloracetic acid (2.5 ml, 10%) was added to the mixture. A portion of the solution (2.5 ml) was mixed with distilled water (2.5 ml) and freshly prepared $FeCl_3$ solution (0.5 ml, 0.1%). The absorbance was read at 700 nm. Increased absorbance of the reaction mixture indicates elevated reducing power. Reducing power is expressed as ascorbic acid equivalent (ASE ml^{-1}). ASE ml^{-1} means that 1 ml sample exhibits the same reducing power as the given amount of ascorbic acid expressed in μmol.

1.6. Copper(II)-chelating activity

The chelating activity of beers on copper(II)-ions was measured according to SHIMADA and co-workers (1992), with a minor modification. Aliquots of sample (0.5–1.0 ml) were added to hexamine buffer (1.0 ml, 10 mM, pH=5.0) containing KCl (10 mM) and $CuSO_4 \cdot 5H_2O$ (3 mM). The reaction mixture was shaken well and after 2 min tetramethylmurexide (0.1 ml, 1 mM) was added. Absorbances at 485 and 530 nm were recorded. Chelating activity was expressed as the absorbance ratio at 485 vs 530 nm. Absorbance ratio of the reaction mixture containing 1 ml of distilled water was 3.55±0.05. Samples having lower absorbance ratios than 3.55 exhibit chelating activity.

1.7. Total antioxidant status

This spectrophotometric technique measures the relative abilities of antioxidants to scavenge the $ABTS^{\cdot+}$ [2,2-azinobis(3-ethylbenzothiazoline-6-sulfonate)] in comparison with the antioxidant potency of standard amounts of 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox). The measurement is based on the procedure described by MILLER and co-workers (1993). The radical cation $ABTS^{\cdot+}$, produced by the ferrylmyoglobin radical generated from methmyoglobin and H_2O_2 in the presence of peroxidase, is a blue-green chromogen with characteristic absorption at 660 nm. In the presence of antioxidants absorbance is decreased. The determination of total antioxidant status (TAS) was carried out using the Randox diagnostic kit with a COBAS MIRA automatic laboratory analyser.

1.8. Statistics

Statistical evaluation was made by SPSS for Windows 9.0, parameters were expressed as mean and standard deviation of three replicate analyses in combined beer samples. Correlations between the polyphenol content and antioxidant properties and significant differences between lager and dark beers ($P<0.05$) were calculated.

2. Results and discussion

The name and the origin of the beers tested in this study are introduced in Table 1. Polyphenol content and antioxidant properties of samples are summarized in Table 2. The polyphenol content of the beers ranged from 270 on the lower end, in the case of Tuborg, to 600 mg l^{-1} detected in a Hungarian dark beer, Borsodi. The polyphenol content of all dark beers was in the higher range, i.e. between 380 and 600 mg l^{-1}. The phenolic content of lager beers ranged from 270 to 470 mg l^{-1}. The average concentration of polyphenols in lager and dark beers was 376 and 473 mg l^{-1}, respectively. The difference between lager and dark beers was statistically not significant. SHAHIDI and NACZK (1995) reported the polyphenol content of beer only 60–100 mg l^{-1}. Regarding our present results, polyphenol content of beers is similar or a bit higher than that of white wines but significantly lower than that of red wines.

White wines contain polyphenols at a concentration range of 250–600 mg l^{-1} (n=5), while red wines have 1000–4000 mg l^{-1} (n=29) (LUGASI, 2001).

Table 2. Polyphenol content and antioxidant properties of beers

No.	Sample	Total polyphenol content[a] (mg l^{-1})	H-donating ability[b] I_{50} (µl)	Reducing power[c] (ASE ml^{-1})	TAS[d] (mmol l^{-1})	Chelating ability[e] (A_{485}/A_{530})	
						0.5 ml	1.0 ml
1.	Chimay	390	64.6	2.61	2.56	1.98	1.71
2.	Tuborg	270	116.3	1.83	1.72	2.39	2.14
3.	Amstel	400	66.7	2.53	2.36	2.05	1.80
4.	Spaten	350	85.8	2.04	1.86	2.08	1.88
5.	Gold Fassl	470	58.5	3.13	2.48	1.95	1.75
	Lager beers average ± SD	376 ± 73	78.4 ± 23.5	2.43 ± 0.51	2.20 ± 0.38	2.09 ± 0.18	1.86 ± 0.17
6.	Leffe	440	56.6	2.69	2.64	2.09	1.81
7.	DAB	380	64.9	2.04	2.06	2.00	1.74
8.	Borsodi	600	37.8	3.36	3.08	2.10	1.65
	Dark beers average ± SD	473 ± 114	53.1 ± 13.9	2.71 ± 0.68	2.59 ± 0.51	2.06 ± 0.06	1.83 ± 0.10

[a] Total polyphenol content is expressed in catechin as reference material. [b] I_{50} is the volume (ml) of the sample that is needed for the 50% discolouration of DPPH radical at 517 nm. [c] Reducing power is given in ascorbic acid equivalent (ASE) that shows the amount of ascorbic acid expressed in µmol whose reducing power is the same as that of 1 ml sample. [d] Total antioxidant status (TAS) is measured by the Randox Kit and the characteristic is expressed in Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) equivalent. [e] Copper-binding ability expressed as absorbance ratio at 485 vs. 530 nm of the sample (0.5 and 1 ml) in a reaction mixture containing copper(II)-ions and tetramethylmurexide in hexamine buffer (pH 5.0). Absorbance ratio of the reaction mixture containing 1 ml of distilled water instead of sample is 3.55±0.05.

The measurement of the polyphenol content does not give information about the chemical characteristics of the compounds having phenolic structure. From hydroxybenzoic acid derivatives, barley contains vanillic and syringic acid (6–17 and 1–22 mg kg^{-1}, respectively), and both are found in malt (12 mg kg^{-1} each) and hops (59 and 30 mg kg^{-1}). These two acids are found at around 0.3–2.2 mg kg^{-1} in different type of beers such as stouts, ales and lagers accompanied by gallic, protocatechuic and 4-hydroxybenzoic acids (0.2–1.8 mg l^{-1}) (MCMURROUGH et al., 1984; HAYES et al., 1987). Beers and hops contain prenyl-flavanones (6- and 8-prenylnaringenin, 6-geranyl-naringenin and 8-prenyl-isoxanthohumol) and prenylchalcones (xanthohumol and desmethylxanthohumol). The profiles varied, and total flavanone and chalcone content ranged from undetectable up to 4 mg l^{-1} (STEVENS et al., 1999).

Low levels of (+)-catechin (<5 mg l^{-1}), (–)-epicatechin (<1 mg l^{-1}), quercetin and myricetin (<0.5 mg l^{-1}) have been reported in lager beers (HERTOG et al., 1993; MADIGAN et al., 1994). Procyanidins and prodelphinidins were found in beers at a

concentration range of 3.5–19.5 mg l^{-1}. Procyanidin dimers and trimers were present in barley and lager beer at a concentration range of 30–360 mg kg^{-1} and 0.1–2.6 mg l^{-1}, respectively (JERUMANIS, 1985; MCMURROUGH, 1996a; 1996b).

TINKILIC and UYANIK (2001) found 66–77 mg l^{-1} tannins in beers. Beer may contain some gallotannins that are added as stabilising agent. They form precipitates with proteins and limit their subsequent precipitation with malt proanthocyanidins and the formation of colloidal haze upon storage. Stabilisation is obtained by addition of up to 10 g hl^{-1} tannic acid 24 h prior to the final filtration (VAN DROMME, 1979). Residual gallotannins could remain in beer if the quantity added exceeds the capacity of the proteins to bind it.

As it can be seen from Fig. 1, beers significantly influenced the discolouration of DPPH radical in concentration-dependent manner. All samples exhibited hydrogen-donating ability. Hydrogen-donating ability is an index of the primary antioxidant activity of the molecules. Primary or chain-breaking antioxidants give hydrogen to free radicals, particularly the lipid hydroperoxide radicals that are the major propagators of the chain autoxidation of fats. This conversion leads to non-radical species, therefore inhibiting the propagation phase of lipid peroxidation. Strong hydrogen-donating ability (I_{50}) was detected in dark beers (37.8–56.6 µl), while weaker effect was observed in lagers (58.8–116.3 µl) (Table 2). H-donor ability of lager and dark beers was not statistically different. At the same time significant correlation was found between the concentration of total polyphenols and the hydrogen-donating activity of beers ($y = 255374x^{-1.3777}$, $R^2 = 0.9619$). In our earlier studies white and red wines showed different hydrogen-donating ability, I_{50} varied between 27.3–80.7 µl in white wines (n=5) and 2.2–16.5 µl in red wines (n=29) (LUGASI, 2000; 2001). Comparing the result of beers and wines, it seems that beers have the same or a bit weaker hydrogen-donating potency than white wines.

All beer samples exhibited strong reducing power at a concentration range of 0.2–1.0 ml (Fig. 2). Reducing power can be interpreted as an index of secondary antioxidant activity. Secondary or preventive antioxidants can reduce the rate of chain initiation in the lipid peroxidation process or can react with the products of lipid peroxidation. This conversion leads to more stable non-radical, non-deleterious products. Reducing power was expressed as ASE ml^{-1} (Table 2). For example 5 ASE ml^{-1} means that 1 ml investigated sample exhibits the same reducing power as 5 µmol ascorbic acid. Significant reducing capacity was found in dark and lager beers as well (2.04–3.39 and 1.83–3.13 ASE ml^{-1}, respectively). No significant difference was found between the two types of beer. A significant linear correlation was found between the reducing power and the polyphenol content of beers ($y = 0.0053x+0.3503$, $R^2 = 0.8675$). As a consequence of lower polyphenol content, reducing power of beers is significantly lower than that of red wines (8.3–32.3 ASE ml^{-1}) (LUGASI, 2000; 2001). Since reducing power of white wines is in a range of 2.2–5.5 ASE ml^{-1}, the effectiveness as reducing agent is nearly the same in white wines and beers.

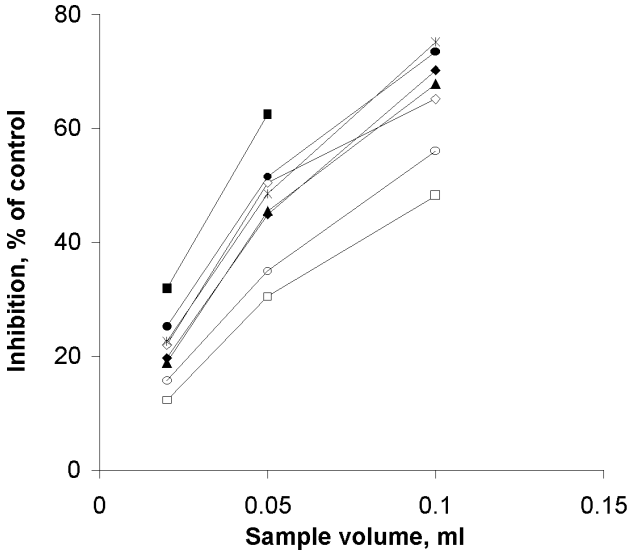

Fig. 1. Concentration-dependent hydrogen-donating ability of beers. -◊-: Chimay; -□-: Tuborg; -▲- Amstel; -○-: Spaten; -*-: Gold fassl; -●-: Leffe; -◆-: DAB; -■- Borsodi

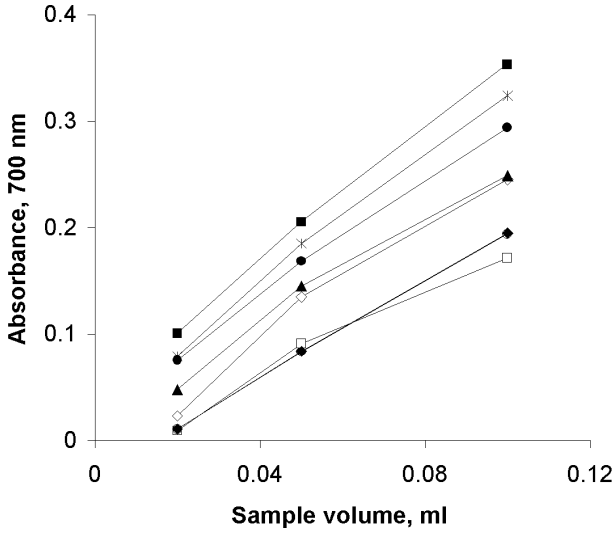

Fig. 2. Concentration-dependent reducing power of beers. -◊-: Chimay; -□-: Tuborg; -▲- Amstel; -○-: Spaten; -*-: Gold fassl; -●-: Leffe; -◆-: DAB; -■- Borsodi

All beer samples showed lower absorbance ratio at 485 vs 530 nm than 3.55 both at 0.5 and 1.0 ml sample volume meaning that biologically active compounds in beer exhibited chelating property (Table 2). It is important to mention that lower value indicates stronger chelating ability because the absorbance ratio at 485 vs. 530 nm of the control mixture (containing distilled water) is 3.55±0.05. However, this ratio is 2.70±0.05, 1.34±0.02 and 0.62±0.01 when the reaction mixture contains 2.25, 2.50 and 2.75 mM EDTA, a well-known chelating substance, respectively (LUGASI, unpublished data).

Chelating ability of beers (1.0 ml) was between 1.65–2.14, the average value was 1.81±0.15. There was no difference between the chelating property of lager and dark beers. Strong correlation was observed between the polyphenol content and chelating ability of beer, the correlation was the strongest when the shape of the curve showed an exponential relation ($y = 10.543x^{-0.2972}$, $R^2 = 0.738$).

Chelating ability of white wines was 2.45±0.06 (n=5) and of red ones 1.86±0.19 (n=29) and there was significant difference between the two types of wines (LUGASI, 2001). Chelating ability of white wines seemed to be very weak, however red ones looked to be more effective as chelators. Opposite to the antioxidant properties reported earlier, the same value of chelating property was detected in beers and red wines. Since plant materials, being the main ingredients of wine and beer, are different, chemical structure of phenolic compounds present in beer are basically different from those of in wines. Although the amount of phenolics in beer is one quarter – one sixth part of the phenols in red wine, it is supposed that phenolics of beer are more capable to form complexes with copper ions than those in white wines.

Although chelating agents such as EDTA are not antioxidants, they play an important role in the prevention of lipid oxidation. During the propagation phase, decomposition of the lipid hydroperoxides catalysed by transitional metal ions (Fe^{2+}, Cu^{2+}) results in an explosive increase of free radicals and consecutive chain reactions. When chelating agents are present these reactions are suppressed. Some compounds such as quercetin, kaempferol or other flavonoids supposed to be present in beer may have chemical structure suitable for chelating transition metal ions and thus can retard the propagation of lipid peroxidation. Flavonoids, as primary antioxidants, have been considered to act as free radical acceptors and chain breakers. Besides those activities, flavonols are known to chelate metal ions, at the 3-hydroxy-4-keto group and/or 5-hydroxy-4-keto group (when the A-ring is hydroxylated at the 5th position) (AFANAS'EV et al., 1989).

Beers possessed significant antioxidant activity measured by Randox kit (Table 2). TAS value was between 1.72–2.56 mmol l^{-1} in lagers and 2.06–3.08 mmol l^{-1} in dark beers. TAS value in lager and dark beer was not significantly different. Strong linear correlation could be calculated between the polyphenol content and TAS value of beers ($y = 0.0043x+0.5893$, $R^2 = 0.8437$). In our earlier study, average TAS values of white and red wines were 2.74±1.4 (n=5) and 11.8±5.3 (n=29), respectively (LUGASI, 2001). Beers, independently of their type, have similar total antioxidant activity as white wines.

3. Conclusions

The characteristic flavour of beer arises from malt, the predominant source of carbohydrate, and hops which are source of bitter compounds. These brewing materials contribute to phenolic and polyphenolic compounds in the early stages of brewing process. Further polymerization of phenolics and formation of polyphenols can occur during wort boiling, and possibly during fermentation and storage of beer. Beer polyphenols furnish colour, impart astringent taste and serve as a reservoir for both oxygen reduction and substrate browning, and participate in precipitation of poorly coagulable beer proteins (SHAHIDI & NACZK, 1995). Phenolic compounds of beer contribute to its flavour quality and are also implicated in non-biological haze formation (KANEDA et al., 1990). Phenolic compounds also contribute to bitterness and astringency of beer and play a role in the harshness of beer and intensify its colour. Some beer phenolics may also act as antioxidants, or may contribute to the formation of carbonyls in beer. Some 67 different phenolic compounds were identified in beer.

In present study the presence of significant amount of polyphenolic compounds in different commercial lager and dark beers was proved and in relation to these chemicals marked antioxidant characteristics were detected in the samples. The extent of antioxidant properties was influenced by the concentration of polyphenols in beers. Total polyphenol content and antioxidant properties, except for chelating ability of beers, were similar to those in white wines, although chemical structure of phenolics are significantly different in the two types of alcoholic beverages as a result of different basic plant materials and production technology.

On the bases of epidemiological and laboratory studies carried out recently, it is supposed that moderate amounts of alcohol may have cardioprotective effects. Several studies reported a higher protection by the consumption of wine. The favourable effects of wine have been attributed to different polyphenolic compounds, among others. However, these or similar compounds are also found in other alcoholic beverages such as beer. In view of the present evidence, there is no "right" or "wrong" drink, only a "right" and "wrong" drinking behaviour regarding absolute amounts, drinking frequency, and accompanying lifestyle and eating pattern (DENKE, 2000; SUTER, 2001). According to scientific results of the last decade, it seems to be proved that moderate consumption of alcohol – 2–3 unit/day for healthy men, and 1–2 unit/day for healthy women (1 unit – 12 g alcohol) –, cannot be criticised either medically or socially. Considering these observations, beer should be a good source of antioxidants accompanied with a well-balanced diet and because of its lower alcohol content than wine the health-damaging effect of ethanol is less pronounced.

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