

## IMPORTANCE OF DETERMINATION OF MACRO AND MICRO ELEMENTS IN WINE

### VAŽNOST ODREĐIVANJA MAKRO I MIKRO ELEMENATA U VINU

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#### SAŽETAK

Sadržaj makro i mikro elemenata u grožđu, moštu i vinu zavisi o mnogim čimbenicima, u prvom redu o sorti, kvaliteti i zrelosti grožđa, sastavu tla, klimi i tehnologiji. Smatra se da postoji pozitivna korelacija između sadržaja makro i mikro elemenata u vinu i osjetilnih svojstava vina. Njihovo postojanje u vinu može poslužiti u vrednovanju autentičnosti vina. Budući da sudjeluju u biokemijskim procesima stanice, makro i mikro elementi privlače pozornost nutricionista. Cilj ovog rada je utvrditi sadržaj kalija, natrija, kalcija, magnezija, cinka i mangana u vinima različitih sorti *Vitis vinifera L.* koje se uzgajaju u Dalmaciji kao i njihovo djelovanje u ljudskom organizmu.

Određivanje elemenata provedeno je pomoću atomskog apsorpcijskog spektrofotometra (AAS) i plamen fotometrije. Promatrane su razlike u koncentraciji mikro i makro elemenata zavisno o sorti i godini berbe. Rezultati pokazuju da su za ljudski organizam, vina dobivena od ispitivanih sorti značajan izvor makro i mikro elemenata, posebice kalija.

#### ABSTRACT

The content of macro and micro elements in grapes, must and wine depends on several factors such as vine cultivar, quality and ripeness of grapes, soil composition, climate and technology, It is considered that there is a positive correlation between the content of macro and micro elements in the wine and sensory properties of wine. Their presence can be regarded as one of the factors in wine authenticity evaluation. Since macro and micro elements take part in biochemical processes of live cell, they attract the attention of nutritionists. The aim of this paper is to determine the content of potassium,

sodium, calcium, magnesium, zinc and manganese in the wines of different cultivars of *Vitis vinifera L.*, which are grown in Dalmatia (Mediterranean part of Croatia) and their activity in human organism.

The elements are determined by atomic absorption spectrophotometry (AAS) and flame photometry. The differences are observed in concentration of particular macro and micro elements depending on the cultivar and vintage year. The results show that wines of investigated grape cultivars are a potential source of macro and micro elements, especially potassium, which are important for human organism.

*Key words:* potassium, sodium, magnesium, calcium, iron, copper, zinc, manganese in wine

## INTRODUCTION

For normal growth of vine, beside elementary nutrition elements (nitrogen, phosphorus, potassium, calcium and magnesium), necessary elements are also iron, copper, zinc, manganese, cobalt, nickel and molibden.

Each particular element is differently present in grapes and wine, and the content of macro and micro elements depends on soil composition, wine cultivar, grape ripeness, climate and the processing method.

Mineral ingredients in the wine have been less frequently studied than organic ones because they were considered less important physiologically and biochemically. However, these ingredients are very important for oenology. Investigations so far have showed significance of particular mineral ingredients in fermentation course, wine quality, oxidoreductional processes as well as activity of different organisms which cause wine deterioration. Positive correlation between micro element content and wine quality has been confirmed so the wines containing more elements have better bouquet and well - marked characteristics of the cultivar (Daničić et al., 1972). Presence of macro and micro elements in wine is very important as the drink is intended for human consumption. Since above mentioned elements enter the tissue liquids and cells composition as biocatalysts and take part in osmotic pressure regulation and acidobasic balance in human organism, they attract the attention of nutritionists (Passmore et al., 1974).

The purpose of this investigation is to determine the contents of macro and micro elements in the wines so that the intake of the elements into the human organism can be evaluated. During the investigation the content of potassium, sodium, calcium, magnesium, zinc, manganese, copper and iron was determined in the wines of different grape cultivars which are grown in Dalmatia (Mediterranean part of Croatia). The results obtained will enable the nutrition value estimation of this drink intended for human consumption.

## MATERIAL AND METHODS

Macro and micro elements determination was carried out on eight wines produced from healthy grapes of *Vitis vinifera* L. species, which are grown in Dalmatian region:

Split - Omiš wine growing hills

Cultivar: Plavac mali

Imotsko polje wine growing hills

Cultivars: Kujundžuša, Trnjak, Vranac, Game

Vrgoračko jezero wine growing hills

Cultivars: Merlot, Cabernet Sauvignon, Plavina.

Wines were produced by classical procedure of maceration in must barrels (5 days). They were analyzed after the second rack off. Calcium, magnesium, sodium, copper, zinc, manganese and iron were determined by atomic absorption spectrophotometry method (AAS - Perkin elmer, model 370) and potassium and sodium by flame photometry method (FF - Carl Zeiss, Falpho 4). results were analyzed by variant method with two variables.

## RESULTS AND DISCUSSION

Wines contain, besides their main ingredients such as water and ethyl alcohol, some nutrients: sugar, vitamins and minerals. That is why they can also have certain energetic properties. Simić, 1977, thinks that smaller amounts of "weak alcoholic drinks" were he places wine, can be recommended for digestion.

Macro and micro elements are substances which enter the organism in quite small amounts with food and water. Since they an play important biocatalytic role, they are often called "inorganic vitamins". Their role in human organism is heterogeneous, but can be reduced to three elementary functions:

- they enter the bone tissue composition taking almost half of the bone solid substance

- they enter the organic compounds composition and are necessary for the maintenance of their function

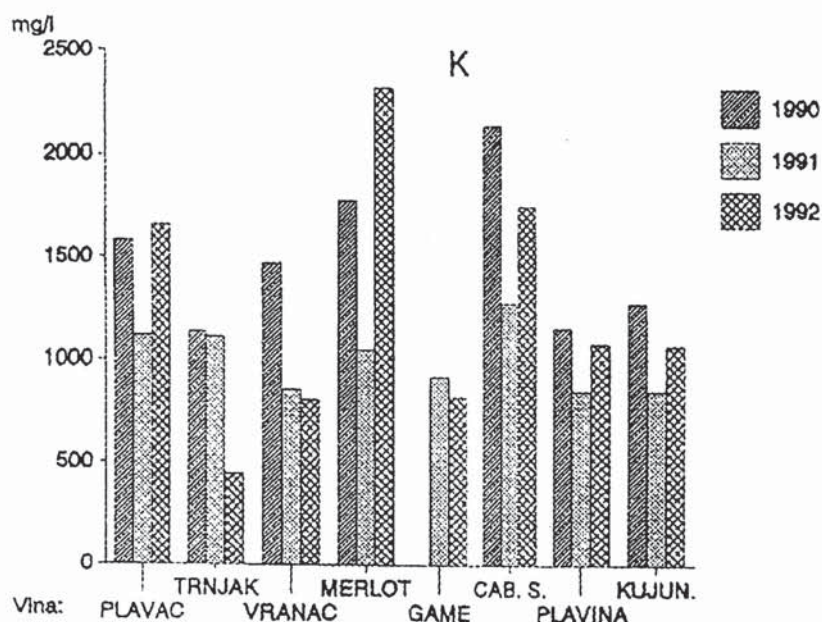
- they enter the tissue liquids compositon and take part in osmotic pressure regulation, acidobasic balance regulation as well as nervous and muscular system stimulation regulation (Passmore et al., 1974).

The content of particular macro and micro elements in the examined wines of different cultivars per vintage year is shown in Figure 1-8. Relative content of the most frequently present mineral ingredients in the wine is shown in Figure 9.

**Potassium** - The content of potassium in the wine depends significantly on wine cultivar, potassium content in the soil climate conditions, wine preservation, alcohol percentage and applied filters. The wines from the areas rich in potassium contain significantly more potassium. The potassium content increase in influenced by potassium fertilizers appliance (Garoglio, 1981).

Potassium concentration in the wines examined ranged from 448 to 2320 mg/l (Fig. 1). The significant influence of cultivar and vintage year is confirmed by significance level of 0.05. The results obtained are in accordance with other authors (Amerine and Ough, 1980). This element plays an important role in the transfer process of neuromuscular stimulation during muscle contraction because it increases the muscular and nervous cells stimulation. It also plays an important role in phosphorization and making glycogen reserves in the cells. Daily needs of the organism in potassium are from 1000 to 1200 mg (Passmore et al., 1974; Karlson, 1978).

Slika 1 Koncentracija kalija u vinima različitih sorti grožđa, berba 1990, 1991, 1992.  
Fig. 1 The concentration of potassium in the wines of different grape cultivars, season 1990, 1991, 1992.



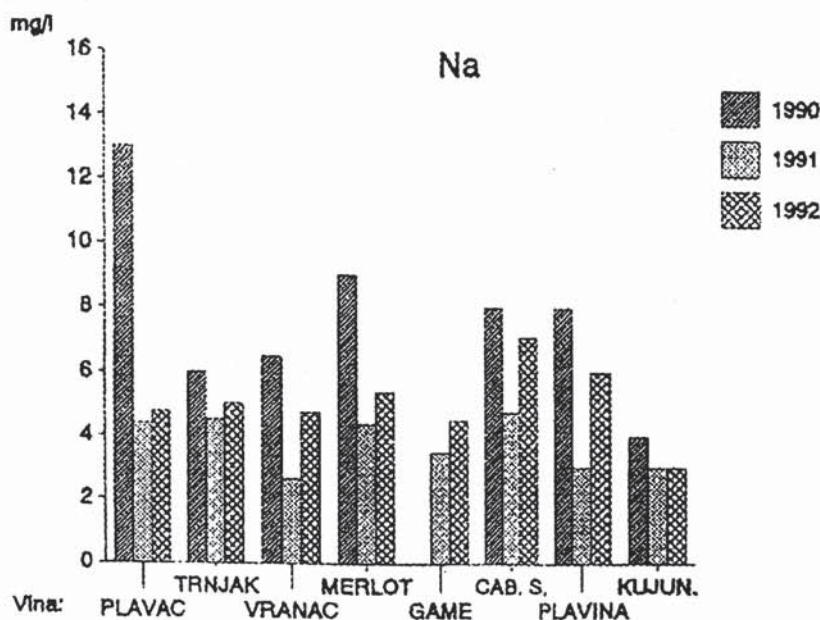
The results of the investigation show that potassium in the most frequent mineral ingredient in the wine (Fig. 9). Large concentrations of potassium

found in wine bring us to the conclusion that this product, when moderately consumed, can be considered the important source of potassium in human nutrition.

**Sodium** - The content of sodium in the wine was rarely determined until the introduction of ion-exchange resins in wine processing. The appliance of sodium sulfite, sodium bisulfite and sodium bentonite contribute to the sodium concentration increase. In order to limit sodium concentration in the wine are prohibited ion-exchange resins appliances in some countries, thus, they are allowed in Italy but not in Germany. The allowed amount of sodium in the wine is not the same in all countries. So allowed sodium concentration in France is 160 mg/l, in Spain 393 mg/l, while in Germany it is 50 mg/l (Amerine and Ough, 1980). According to Amerine and Ough, 1980; European and American wines contain 6 to 309 mg/l of sodium, while according to the results of our investigations the amount of sodium in the examined wines ranged from 3 to 13 mg/l of the wine (Fig. 2). The significant influence of the vintage year is confirmed.

Slika 2 Koncentracija natrija u vinima različitih sorti grožđa, berba 1990, 1991, 1992.

Fig. 2 The concentration of sodium in the wines of different grape cultivars, season 1990, 1991, 1992.



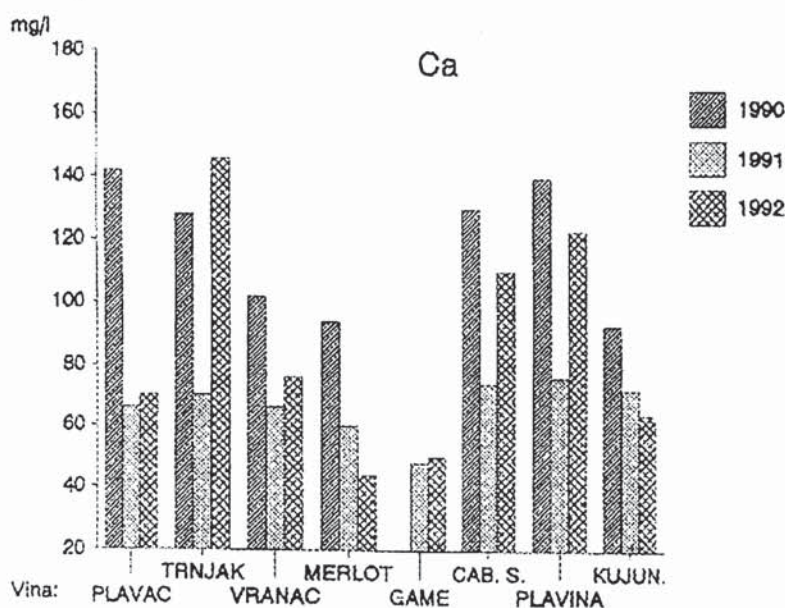
Sodium plays an important role in maintaining the acidobasic balance and osmotic pressure, serves to transfer CO<sub>2</sub> from tissue to the lung and plays a role in muscle stimulation regulation, especially the heart. Daily needs for sodium are from 5 to 10 mg (Passmore et al., 1974; Karlson, 1978).

Nutritionists recommend in hypertension diets the biggest possible ratio of potassium and sodium. Because of the low content of sodium and the high content of potassium in the examined wines, it can be said that these wines have very suitable ratio of K/Na which may indicate their appliance potential in dieting for hypertension (Amerine and Ough, 1980).

**Calcium** - In contrast to potassium the grapes and wine contain significantly lower amounts of calcium. The content of calcium in the wine depends on soil type, wine pH, alcohol percentage, time, method and temperature of wine storage as well as the applied means in the clarification and desour of wine (Amerine and Ough, 1980). Higher calcium concentrations can be found in the wines stored in concrete cisterns without adequate isolation.

Slika 3 Koncentracija kalcija u vinima različitih sorti grožđa, berba 1990, 1991, 1992.

Fig. 3 The concentration of calcium in the wines of different grape cultivars, season 1990, 1991, 1992.



Insufficient calcium intake with food is accompanied by disorders in ossification, blood coagulation potential reduction and increased stimulation of nervous and muscular system. Daily needs for calcium are from 400 to 500 mg (Passmore et al., 1974; Karlson, 1978).

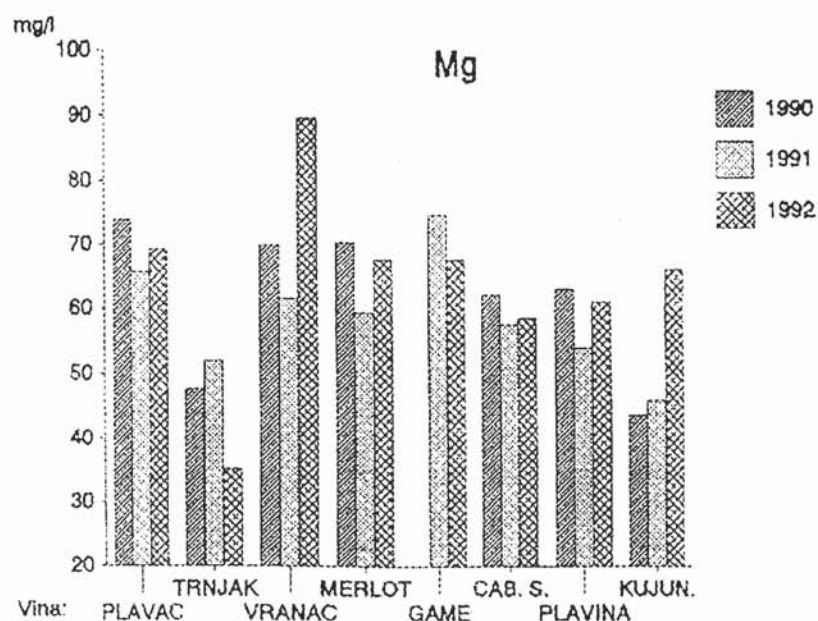
The content of calcium in the examined wines ranged from 48 to 146 mg/l (Fig. 3). The significant influence of cultivar and vintage year is confirmed. The obtained results are in accordance with the results of other authors which show that content of calcium in Italian wines ranged from 40 to 170 mg/l, and in American wines from 6 to 117 mg/l (Amerine and Ough, 1980).

**Magnesium** - After potassium and calcium, magnesium is the most important cation in the wine. Magnesium concentration is influenced by the use of ion-exchange resins, alcohol concentration, wine pH, temperature and time of storage. It is thought that magnesium plays an important role in tartrate stability and the acid taste (Amerine and Ough, 1980).

According to Amerine and Ough, 1980, magnesium concentration in American and European wines ranges from 21 to 173 mg/l. Italian wines contain a little more magnesium than calcium (Garoglio, 1981). According to Daničić et al. 1972, magnesium concentration in wine ranges from 1.2 to 9.8 mg/l and is significantly lower than calcium concentration. According to our investigations magnesium concentration in the examined wines ranges from 35.2 to 74.8 mg/l (Fig. 4). The significant influence of the cultivar has been confirmed while the vintage year does not show significant.

Slika 4 Koncentracija magnezija u vinima različitih sorti grožđa, berba 1990, 1991, 1992.

Fig. 4 The concentration of magnesium in the wines of different grape cultivars, season 1990, 1991, 1992.



Magnesium takes part in maintenance of protein molecules cohesion and in enzyme processes but above all in carbohydrates metabolism. Daily needs are from 200 to 300 mg/l (Passmore et al., 1974; Karlson, 1978).

**Iron** - Iron is a very important mineral ingredient of wine and a component of many compounds in wine it gets into grapes from the soil in the amount providing iron concentration up to 10 mg/l (Daničić et al. 1972). Higher iron concentrations are the result of grape pollution with soil and dust particles or of

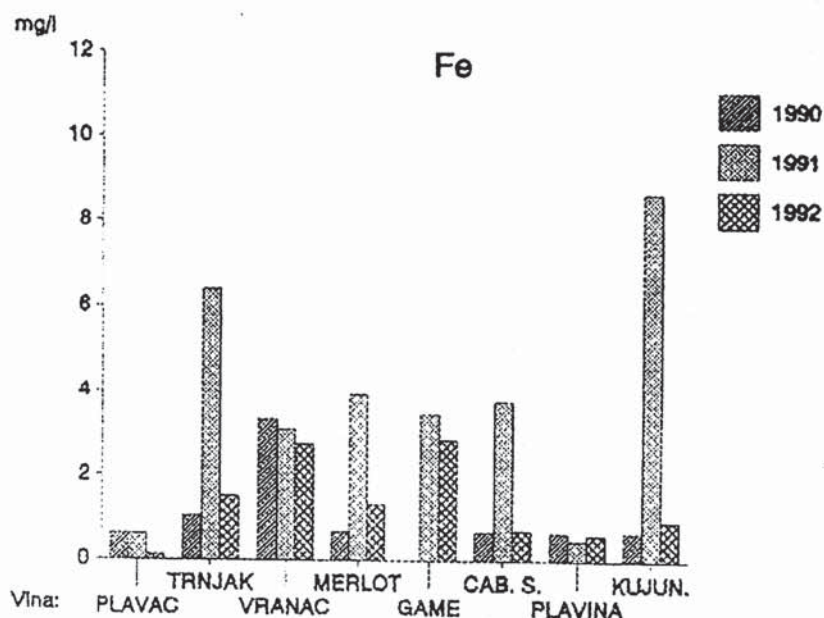
the must and wine contacts with unprotected metal parts of the processing machine. The content of iron in the wine should not be higher than 5 to 7 mg/l, because higher concentrations are one of the instability factors of wine (grey gleam, change of color). Iron acts as a catalyst of oxidation processes, and is one of the important oxidoreductional processes regulators in the wine. Its role in aging and stabilization processes of wine is indisputable (Amerine and Ough, 1980). Besides, the presence of iron in wine is of great importance bioenergetically for this drink is intended for everyday use.

Iron plays an important role in hemoglobin synthesis, and serum iron influences the immunity of organism. Daily needs are from 9 to 28 mg (Passmore et al., 1974; Karlson, 1978).

The content of iron in the examined wines ranged from 0.12 to 8.67 mg/l (Fig. 5). The significant influence of vintage year was confirmed while the differences depending on cultivar were noticed but were not of importance. The data obtained are in accordance with the data of other authors (Amerine and Ough, 1980).

Slika 5 Koncentracija željeza u vinima različitih sorti grožđa, berba 1990, 1991, 1992.

Fig. 5 The concentration of iron in the wines of different grape cultivars, season 1990, 1991, 1992.

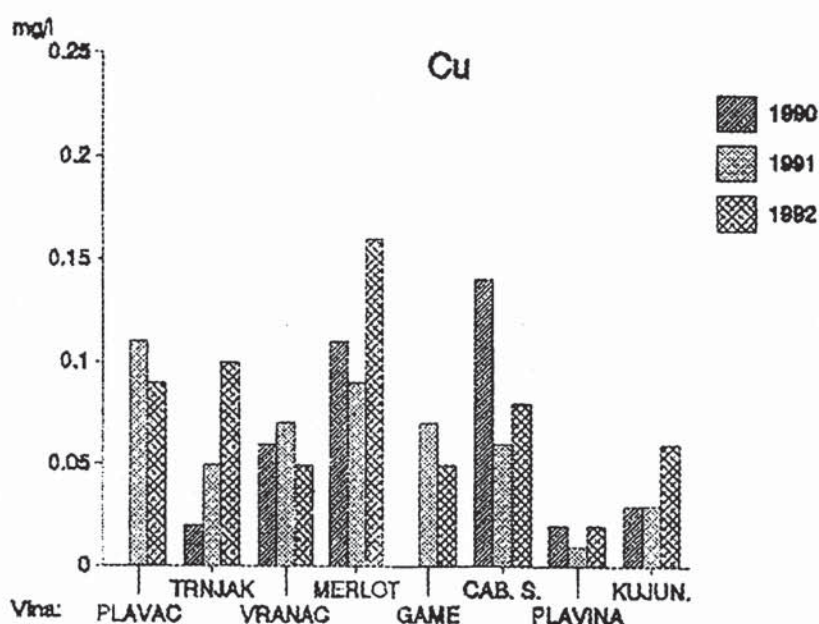


**Copper** - Must and wines contain small amounts of copper, around 0.1 to 0.3 mg/l (Amerine and Ough, 1980). The increased content of copper can be the result of copper-based preservatives as well as wine must contacts with materials containing copper during processing and final processing. Presence



of copper in wine also one of the instability factors because of protein compounds forming easily resulting in wine turbidity. Copper concentration in the examined wines ranged from 0.01 to 2.24 mg/l (Fig. 6) which is in accordance with literature data (Amerine and Ough, 1980; Daničić et al. 1972). The significant influence of cultivar vintage year is not confirmed.

Slika 6 Koncentracija bakra u vinima različitih sorti grožđa, berba 1990, 1991, 1992.  
 Fig. 6 The concentration of copper in the wines of different grape cultivars, season 1990, 1991, 1992.

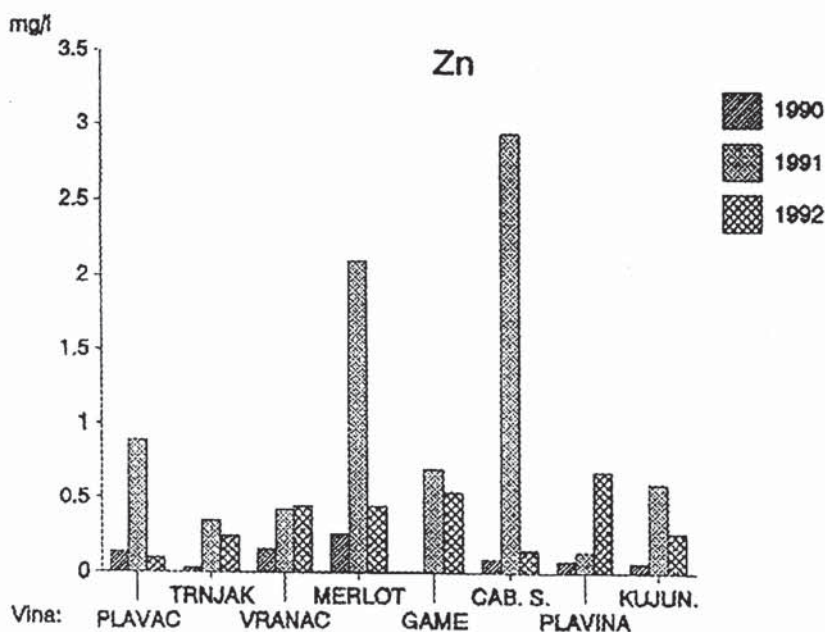


Copper plays a role of a catalyst in the hemoglobin emerging process, the erythrocyte creation process as well as in pigment and keratin growth and creation. Daily needs are from 0.6 to 2 mg (Passmore et al., 1974; Karlson, 1978).

**Zinc** - Zinc is found in all parts of vine. It is very significant for growth and development of wine as well as fermentation activation. It can get into wine from solid parts of grapes rich in zinc, from derification means based on zinc and as the result of contacts with metal parts of processing machines. It is thought that zinc-based insecticide appliance does not increase the content of zinc in wine (Amerine and Ough, 1980).

The content of zinc in German wines ranges from 0 to 7.8 mg/l, in Italian wines from 0.12 to 6.05 mg/l and in Californian wines from 0.13 to 1.67 mg/l (Amerine and Ough, 1980). According to our investigations zinc concentration in the examined wines ranged from 0.03 to 2.24 mg/l (Fig. 7). Statistical data analysis confirmed the significant influence of vintage year while the differences depending on cultivar were noticed but were not of importance.

Slika 7 Koncentracija cinka u vinima različitih sorti grožđa, berba 1990, 1991, 1992.  
 Fig. 7 The concentration of zinc in the wines of different grape cultivars, season 1990, 1991, 1992.



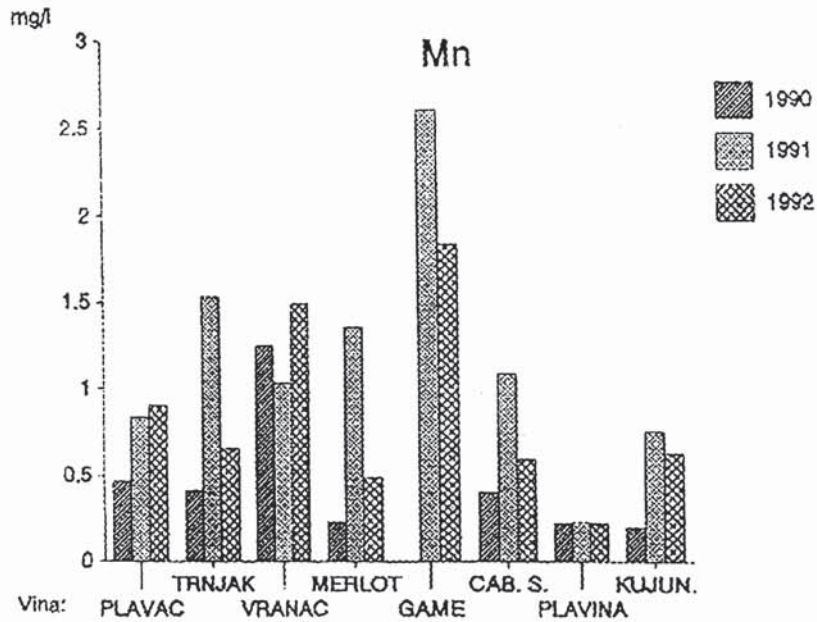
Zinc plays an important role in the pancreas endocrine function for it enters the insulin molecules composition. It is also important for sugar and protein metabolism as well as the growth process. Daily needs for zinc are from 9.8 to 14 mg (Passmore et al., 1974, Karlson, 1978).

**Manganese** - Manganese is found in all parts of vine and its physiological role is very important. It can mostly be found in buds and leaves but less frequently in grapes. More of it is found in solid parts of grapes and less in juice so that the content of manganese in wine depends on the processing method. Its presence in wine is very important for wine quality and microflora (Radovanović, 1986).

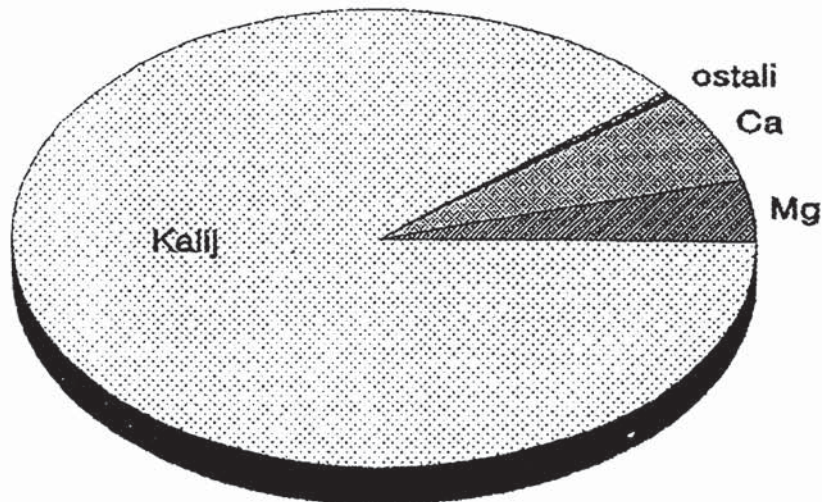
According to our investigations manganese concentration in the examined wines ranged from 0.20 to 2.61 mg/l (Fig. 8). The significant influence of cultivar and vintage year is confirmed. The content of manganese in Italian wines varies from 0.53 to 1.65 mg/l, in German from 0.24 to 2.25 mg/l, in Bulgarian from 0.14 to 1.75 mg/l and in Californian from 0.65 to 2.03 mg/l (Amerine and Ough, 1980), which is in accordance with our results.

Manganese plays an important role of a respiratory coenzyme, helps hemoglobin synthesis and is important for calcium and phosphorus metabolism as well as for maintenance of reproduction potential of organism. Daily needs are from 6 to 8 mg/l (Passmore et al., 1974; Karlson, 1978).

Slika 8 Koncentracija mangana u vinima različitih sorti grožđa, berba 1990, 1991, 1992.  
 Fig. 8 The concentration of manganese in the wines of different grape cultivars, season 1990, 1991, 1992.



Slika 9 Prosječni relativni udio mineralnih sastojaka u vinu  
 Fig. 9 The average relative content of mineral elements in wine



The results of the investigations show that wines such as Plavac, Trnjak, Vranac, Merlot, Cabernet Sauvignon, Plavina and Kujundžuša, produced by maceration in must barrel procedure are very interesting as the source of macro and micro elements, especially of potassium. Since wine is a part of everyday

nutrition it would be good to think about production of wines of lower alcohol concentration to enable the intake of nutritional elements without risks related to alcohol.

## CONCLUSIONS

The examined wines contain potassium, sodium, calcium, magnesium, iron, copper, zinc and manganese in a high range of concentrations. The most frequent cations in the wine are potassium, calcium and magnesium. The average content of potassium and sodium in one liter of wine is suitable for human daily needs, while the other macro and micro elements are present in the amount which can satisfy the daily needs.

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