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MAGNESIUM CONTENT IN CAULIFLOWER AT SALES PLACES IN ZAGREB

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ABSTRACT

Cauliflower (*Brassica oleracea* var. *botrytis*) is a biennial crop belonging to the mustard family. It is grown for a head consisting of a thick, short, hypertrophied flower stem with undifferentiated flowers and flower embryos. The minerals that are most abundant in cauliflower are sodium, potassium, magnesium, calcium, phosphorus, iron, and sulfur. Magnesium is an essential element for almost all living beings, it is involved in many processes such as the synthesis of organic substances, it is responsible for the activation of a large number of enzymes and has a beneficial effect on the metabolism of carbohydrates, proteins and fats. The aim of this article was to determine the content of magnesium in cauliflower available in the city of Zagreb and to determine how much magnesium can be settled by consuming that cauliflower. The sampling was carried out at 9 sales places in the city of Zagreb, of which 3 were stores with organic products, 3 markets and 3 retail chains. Magnesium was determined by atomic absorption spectrometry after digestion with concentrated HNO_3 and $HClO_4$ in a microwave oven. The magnesium content of cauliflower ranged from 0.17 to 0.22% Mg in dry matter, 21.24 to 38.87 mg Mg/100 g in the fresh matter, and it was found that consuming 100 g of cauliflower can satisfy 5.98-10.75% of our daily need for magnesium.

Key words: *Brassica oleracea* var. *botrytis*, food, minerals, nutrients, vegetable.

INTRODUCTION

Plant species allow people to satisfy their basic needs, such as clothing, shoes, medicines, raw materials for the production of various items, but especially as food. When people eat vegetables, they know that they intake into their bodies significant amounts of minerals, as well as vitamins and other specialised metabolites, but they do not know exactly how much of them is contained in the food consumed. Therefore, there is a need for more detailed labeling of foods made from fruits and vegetables. Cauliflower (*Brassica oleracea* var. *botrytis*) is a biennial crop grown for its metamorphosed flower heads. The main part of the roots is located at a depth of 30 cm, and the height of the aerial part ranges from 15 to 40 cm. The leaves are oblong, with a wavy or straight margin, 25 to 45 cm long and up to 15 cm wide, with a prominent main vein (Parađiković, 2009; Matotan, 2008). The edible part is a solid and compact flower head that can have various shapes and colors and consists of a thick, short, hypertrophic pedicel with undifferentiated inflorescences and flower buds. The head shape can be hemispherical and conical with more or less pronounced lateral branches, that is, more or less bumpy. The color of the flower head can be white, ivory, yellow, orange, green, pink and crimson, with the white flowers being the most appreciated.

When the white flower is exposed to direct sunlight for several hours, the color changes from white to ivory to brown (Lešić et al., 2016). Cauliflower flowers are available on the market throughout the year and are most commonly consumed as a salad, fresh, seasoned, or cooked, and are well known as a dietary food. Cauliflower contains 2.35% protein, 0% crude fat, 4.71% carbohydrate, and 2.4% dietary fiber (USDA, 2017). The minerals that are quantitatively most abundant in cauliflower are sodium (10-24 mg/100 g fresh weight), potassium (295-310 mg/100 g fresh weight), magnesium (0.2-17 mg/100 g fresh weight), calcium (17-31 mg/100 g fresh weight), phosphorus (30-72 mg/100 g fresh weight), iron (0.3-1.4 mg/100 g fresh weight), and sulfur (up to 80 mg/100 g fresh weight) (Lešić et al., 2016). Magnesium has a number of key functions in plants. Metabolic processes and reactions in plants that require Mg include photophosphorylation (e.g., the formation of ATP in chloroplasts), photosynthetic carbon dioxide fixation, protein synthesis, chlorophyll formation, phloem flow, photoassimilate partitioning and utilisation, reactive oxygen species formation, and photooxidation (Cakmak and Yazici, 2010). The average magnesium content in the dry matter of plants is 0.1-1.0%, and 0.15-0.35% in the dry matter of well-supplied plants. Reproductive organs are rich in magnesium, and in plants, there is an average of 50% free magnesium, which is why the Mg^{2+} ion is a very important electrolyte (Vukadinović and Vukadinović, 2011). The best-known role of Mg^{2+} in photosynthesis is as the central atom of the chlorophyll molecule. Magnesium also plays a role in the "light" and "dark" reactions of photosynthesis. In the "light" reaction, light enhances the pumping of protons from the stroma to the thylakoids, and the resulting proton gradient facilitates the conversion of ADP and NADP+ to ATP and NADPH. In the so-called "dark" reaction (which actually occurs during the day and requires some of its enzymes to activate light-dependent processes), enzymes in the stroma use energy-rich compounds produced in the "light" to reduce CO_2 to carbohydrates (Shaul, 2002). In the "dark" reaction, Mg^{2+} activates the enzyme ribulose-1,5-diphosphate carboxylase (Rubisco), which initiates the carboxylation of ribulose-1,5-diphosphate, leading to CO_2 fixation (Portis, 1992). Magnesium ranks fourth among the cations in the human body. The body of an adult contains 24 g of magnesium, 99% of which is found in the bones, skeletal muscles, kidneys, liver, and heart (Medić-Šarić, 1997). It is second the most abundant intracellular cation, which plays an important role in cellular functions. It is involved in more than 300 enzymatic reactions in the body, including the metabolism of glucose, lipids, proteins, and nucleic acids, the synthesis of the H_2 transporter, and all reactions associated with the formation and use of adenosine triphosphate (ATP) (Laires et al., 2004). Magnesium deficiency disrupts the cellular potassium gradient, leading to loss of potassium in the cell and accumulation of sodium, and can cause increased blood clotting; the clinical signs are muscle tremors, weakness, nausea, vomiting, dysphagia, and tetany (Medić-Šarić, 1997.).

According to the National Institutes of Health of the USA (NIH, 2022), the recommended daily magnesium intake for infants up to 6 months is 30 mg, 7-12 months 75 mg, 1-3 years 80 mg, 4-8 years 130 mg, 9-13 years 240 mg, and for adults over 14 years 310-420 mg, while the recommended daily magnesium intake for adults of the European Union Regulation on the provision of food information to consumers is 375 mg (Regulation EU No. 1169/2011).

The aim of this work is to determine the amount of magnesium in metamorphosed cauliflower flowers at different points of sale in the city of Zagreb.

MATERIALS AND METHODS

For this study, samples of white coloured metamorphosed cauliflower (*Brassica oleracea* var. *botrytis*) were sampled in the city of Zagreb to determine the magnesium content in cauliflower. On November 15, 2018, cauliflower was sampled in triplicate in 3 retail chains (RC) (Konzum-RC1, Spar-RC2 and Kaufland-RC3), 3 markets (M) (Dolac-M1, Kvatrić-M2 and Trešnjevka-M3) and 3 organic products stores (OPS) (Eko Sever-OPS1, bio&bio-OPS2, Garden-OPS3) in the area of Zagreb city.Information on cauliflower cultivation was obtained by consulting the declaration or by verbal discussions with traders at the point of sale. The cauliflower samples from the retail chains were not labeled as organic products, so it is assumed that they are conventionally grown and that mineral fertilizers were used during cultivation. In conversation with the retailers, it was determined that manure and mineral fertilizer were used in the cultivation of cauliflower sampled at sales point Dolac-M1, manure and eco-fertilizer were used in the cultivation of cauliflower sampled at sales point Kvatrić-M2, and NPK 15-15-15, KAN and cattle and horse manure combined with pelleted chicken manure were used in the cultivation of cauliflower sampled at sales point Trešnjevka-M3. All cauliflower samples from organic products' stores are from organic cultivation, as these stores sell only organically grown products with the appropriate organic label. After collection, the average cauliflower samples were delivered to the Analytical laboratory of the Department of Plant Nutrition, Faculty of Agriculture, University of Zagreb, where chemical analysis of cauliflower flower head samples was performed. The cauliflower samples were freed from the leaves and then chopped and ground. The samples were dried at 105 °C and then milled and homogenized. For the determination of magnesium content, the milled samples were digestated with concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$) in a microwave oven, after which magnesium was determined by atomic absorption spectrometry - AAS (AOAC, 2015). The dry matter was determined gravimetrically by drying to a constant mass. Statistical data processing was performed using the analysis of variance model (ANOVA). The program SAS System for Win. ver. 9.1 (SAS Institute Inc.), and Tukey's test of significant thresholds was used to test the results (SAS, 2002-2003).

RESULTS AND DISCUSSION

Figure 1 shows the average dry weight content (DW) of cauliflower sampled in retail chains, markets and, organic products stores. The total dry weight content in the sampled cauliflower ranged from 6.70 to 7.00% DW. The highest average dry weight value was found in cauliflower samples from retail chains and was not statistically significantly different from cauliflower samples from organic products stores or markets. Figure 2 shows the values of dry weight according to the sales points. The highest value was found in cauliflower from Spar-RC2 (7.93% DW), and the lowest in cauliflower from Trešnjevka market-M3 (6.20% DW). According to Parađiković (2019), the percentage of dry weight in cauliflower is 11-13% DW, which is higher than the values determined in this study.

Figure 3 shows the magnesium content expressed as a percentage of dry matter. The highest average value for magnesium in dry weight was found in cauliflower samples from organic products stores (0.22% Mg DW) and is significantly different from the values of samples from retail chains (0.17% Mg DW) and markets (0.18% Mg DW). Figure 4 shows the values of magnesium content in dry weight (%Mg DW), ranging from 0.15% Mg DW (Market Kvatrić-M2 and Kaufland-RC3) to the highest value of 0.25% Mg DW (Eko Sever-OPS1) and differing significantly from each other. Figure 5 shows the value of magnesium content expressed in mg Mg/100 g of fresh weight. The analysis of the samples showed that the average value of the samples from organic products stores (33.34 mg Mg/100 g fresh matter) was significantly higher compared to the value of the samples from retail chains (23.91 mg Mg/100 g fresh weight) and markets (26.86 mg Mg/100 g fresh matter). Figure 6 shows the magnesium

content in the fresh weight depending on the points of sale. The statistically highest value was found in cauliflower at Eko Sever-OPS1 with a value of 38.87 mg Mg/100 g fresh weight. The lowest value was 21.24 mg Mg/100 g fresh weight in cauliflower at Kaufland-RC3 sales point. Cauliflower samples from market Kvatrić-M2 (21.50 mg Mg/100 g fresh weight) and Spar-RC2 (22.27 mg Mg/100 g fresh weight) had similar values.

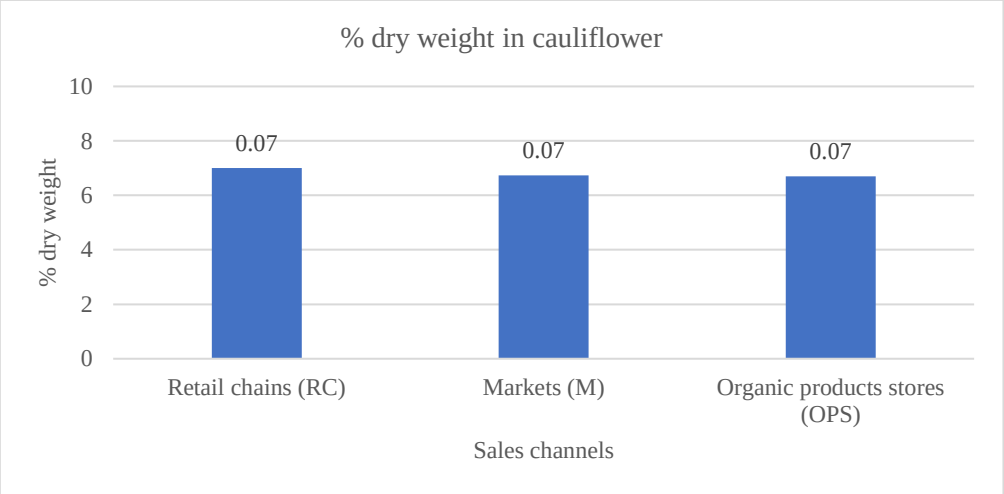

Figure 1. Dry weight (% DW) content determined in cauliflower samples collected from different sales channels

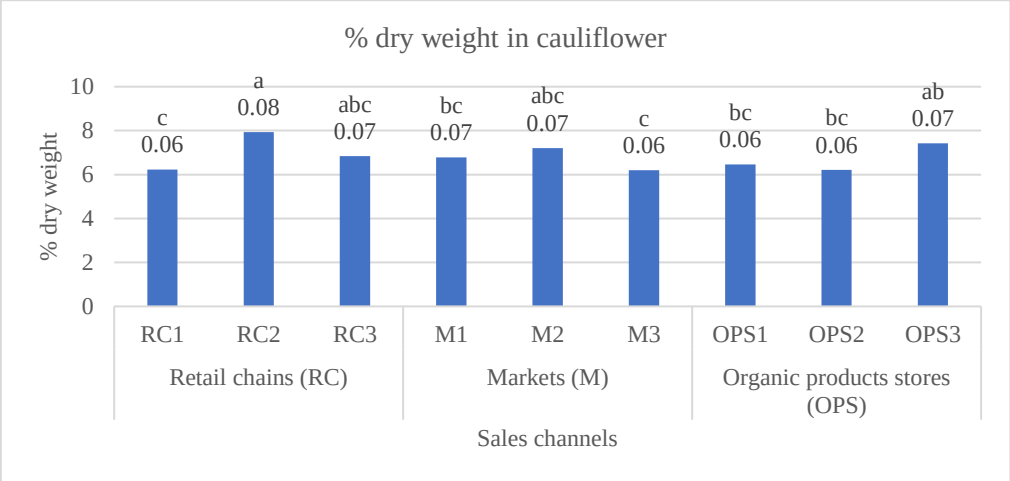

Figure 2. Dry weight (% DW) content determined in cauliflower samples collected from retail chains, markets and organic product stores. (Different letters represent significantly different values according to Tukey's test.)

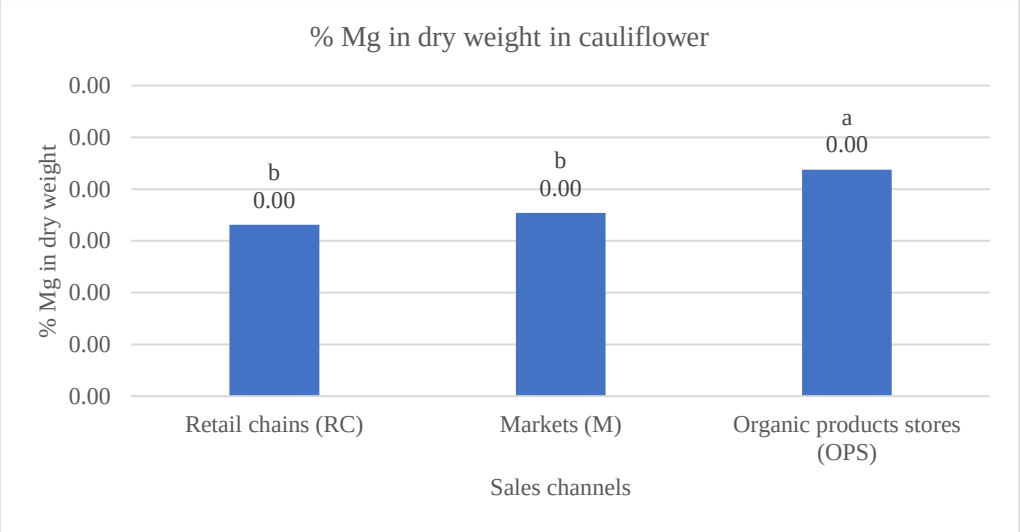

Figure 3. Magnesium content in dry weight determined in cauliflower samples collected from different sales channels. (Different letters represent significantly different values according to Tukey's test.)

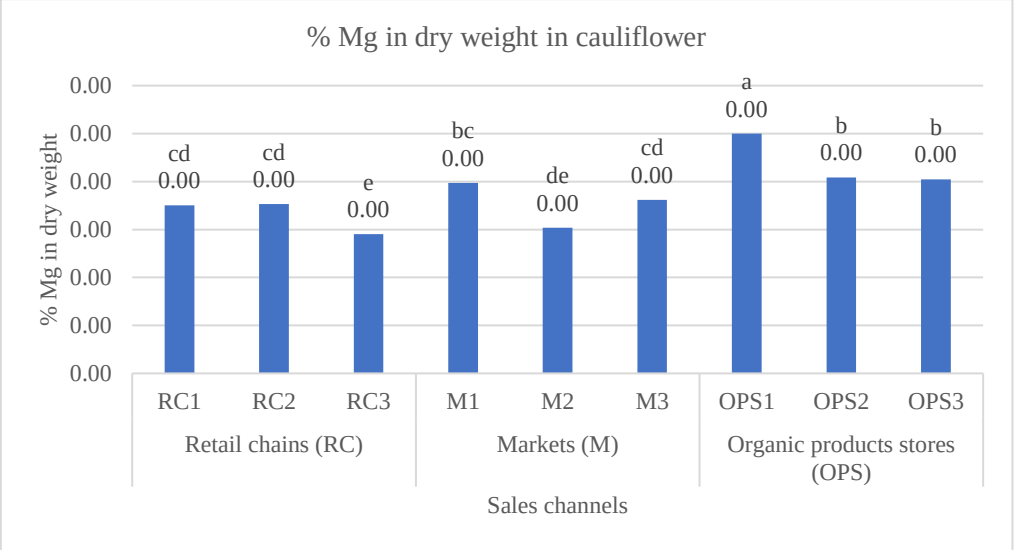

Figure 4. Magnesium content in dry weight determined in cauliflower samples collected from markets, retail chains and organic product stores. (Different letters represent significantly different values according to Tukey's test.)

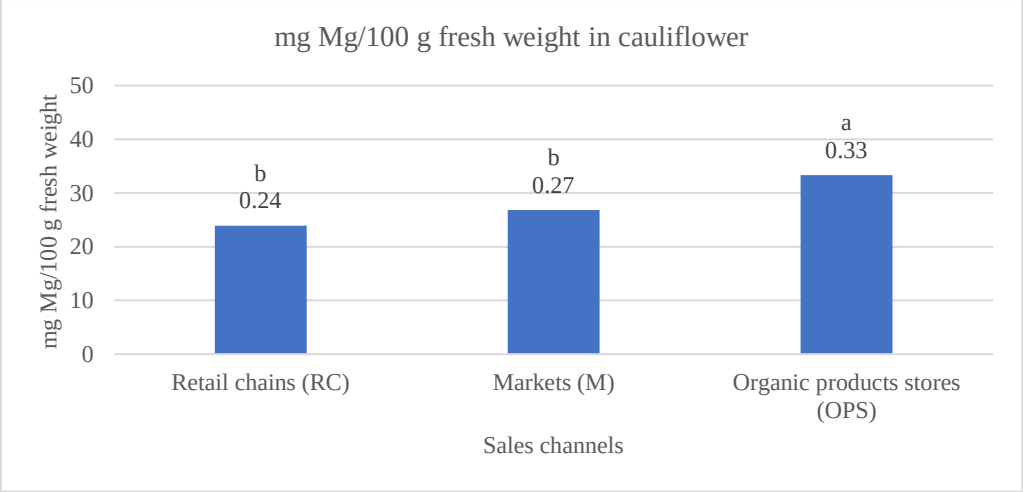

Figure 5. Magnesium content in fresh weight determined in cauliflower samples collected from different sales channels. (Different letters represent significantly different values according to Tukey's test.)

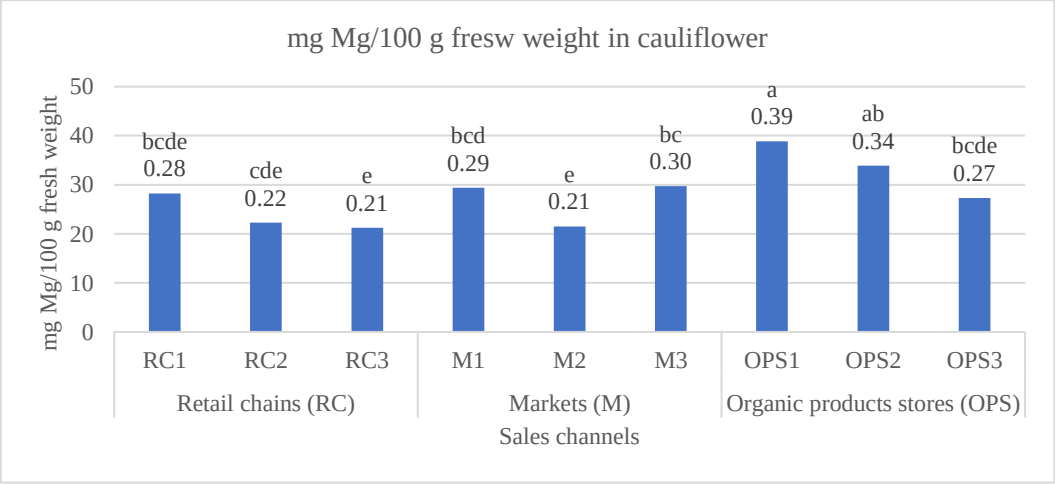

Figure 6. Magnesium content in fresh weight determined in cauliflower samples collected from markets, retail chains and organic product stores. (Different letters represent significantly different values according to Tukey's test.)

According to Lešić et al. (2016), the cauliflower magnesium content in fresh weight range 0.2-17 mg/100 g, USDA (2018) reports the magnesium content as 15 mg Mg/100 g, and TWHF (2019) as 11.16 mg/100 g. The results of the analysis are significantly higher compared to the literature data. In the cultivation of cauliflower from retail chains, a conventional production method was applied, using mineral fertilizers, which contain more nutrients compared to organic fertilizers. The higher magnesium contents in cauliflower from retail chains can therefore be attributed to the use of mineral fertilizers. With the consumption of 100 g of organically produced cauliflower, men can cover 8.13 and women 10.75% of the daily Mg intake. With the consumption of 100 g of cauliflower from retail chains, men can cover 5.98% and women 7.71% of the daily Mg intake, and with the consumption of 100 g of cauliflower from markets, men can cover 6.71% and women 8.66% of the daily Mg intake.

CONCLUSIONS

The determined magnesium content in the dry weight of cauliflower ranged from 0.17 to 0.22% Mg DW. The determined magnesium content in the fresh weight ranged from 21.24 to 38.87 mg Mg/100 g fresh weight. The highest magnesium content in dry and fresh weight of cauliflower was found in samples from organic products stores. The consumption of 100 g of fresh cauliflower from the conducted studies can cover the daily requirement of magnesium by 5.98-10.75%. It would be good to extend such studies to the whole calendar year.

REFERENCES

AOAC (2015). *Officinal Method of Analysis of AOAC International*. Gaithersburg, Maryland, USA.

Laires, M.J., Monteiro, C.P., Bicho, C.P. (2004). Role of cellular magnesium in health and human disease. *Frontiers in Bioscience, 9*, 262-276.

Lešić, R., Borošić, J., Buturac, I., Herak Ćustić, M., Poljak, M. & Romić, D. (2016). *Povrćarstvo*. lll. Dopunjeno izdanje. Zrinski. Čakovec

Matotan, Z. (2008). *Zeljasto povrće*. AZ Promo, Bjelovar

Medić-Šarić, M. (1997). *Vitamini i minerali*. Zagreb

NIH (2019). *National Institutes of Healht of USA*
https://ods.od.nih.gov/factsheets/Magnesium-HealthProfessional/ (accessed : 7.8.2019.

Parađiković, N. (2009.) *Opće i specijalno povrćarstvo*. Osijek, Poljoprivredni fakultet u Osijeku

Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004

TWHF - *The World's Healthiest Foods*. (2019).
http://www.whfoods.com/genpage.php?tname=foodspice&dbid=13 (accessed 18 June 2019)

USDA - *United States Department of Agriculture*. (2018).
https://ndb.nal.usda.gov/ndb/foods/show/11135?fgcd=&manu=&format=&count=&max=25&offset=&sort=default&order=asc&qlookup=cauliflower&ds=&qt=&qp=&qa=&qn=&q=&ing= (accessed 13 May 2018)

Vukadinović, V. & Vukadinović, V. (2011). *Ishrana bilja*. Poljoprivredni fakultet u Osijeku, Osijek