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BIOCHEMICAL ANALYSIS OF SOME BIOACTIVE COMPOUNDS IN FIVE MAIZE CULTIVARS (*ZEA MAYS* L.)

Popoviciu Dan Răzvan*, Panaitescu Liliana, Stroe Ciprian-Traian
„Ovidius" University of Constanţa, Faculty of Natural Sciences and Agricultural Sciences, Constanţa, Romania
** Correspondence author. E-mail: dr_popoviciu@yahoo.com*

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ABSTRACT

Five maize hybrids grown in local farms, in Constanța county, were analyzed for determining bioactive compounds contents. They were found to have variable carotenoid contents, between 17–69 mg/kg, with lutein and lycopene being the most important. Phenolic inventory ranged between 6,016-16,326 mg/kg, of which phenolic acids were dominant (77–87%), followed by flavonoids (13–23 %). Ascorbic acid content ranged between 265-682 mg/kg. Free soluble sugars were 20,883–39,134 mg/kg, while lipid oil, with 22,000–36,333 mg/kg.
Among the selected cultivars, DKC 5810 scored highest in terms of total carotenoids, lutein, xanthins, total phenolics, flavonoids, anthocyanins, phenolic acids; KWS 4484 also hosted high amounts of phenolics, also scoring highest in terms of tannins, stilbenes and oils; SY Torino was first in terms of lycopene, coumarins, ascorbic acid (but with the lowest phenolic inventory); DKC 4391 had the highest free sugar amount.

INTRODUCTION

Maize or corn (*Zea mays* L.) is a major component of human diet, maize grains and their derivatives are a key source of starch, soluble sugars and lipid oil.

However, it is known that maize also hosts many other valuable nutrients, more and more subject to scientific research, due to their benefits to human health. These include a wide array of carotenoids, ascorbic acid and especially the wide group of phenolic compounds.

Various studies show that such compounds have various bioactive properties such as antitumoral, neuroprotective, antiobesity, and generic antioxidant ones (Cristianini et al. 2020, Navarro et al. 2018).

The objective of this paper was to determine the bioactive compounds contents in five maize hybrids widely grown in Dobruja region.

MATERIAL AND METHODS

Five maize hybrids, namely DKC 4109, DKC 4391, DKC 5810 (all produced by Bayer), KWS 4484 (KWS), and SY Torino (Syngenta), were taken into analysis. Samples were taken from local farmers in central Cernavodă plateau, middle Carasu Valley, Constanța countyand taken for laboratory analyses to the „Ovidius" University.

According to the producer, Bayer Dekalb DKC 4109 is an a early hybrid (FAO 300-340 group), average-flowering, with low to median cob insertion and dentate grains, drought-resistant, highly adaptable. Bayer Dekalb DKC 4391 is an early hybrid (FAO 300-340), similar to the previous, with a higher drying rate. Bayer Dekalb DKC 5810 is a late hybrid (450-490), with higher flowering capacity and good phytosanitary resistance (Agro Bayer România). KWS 4484 is early to medium (FAO 380), with tall stem and average seed number, tolerant to drought and fall (Popescu et al. 2016). SY Torino is an early variety (FAO 300-340), with high productivity and high drying rate (Syngenta).

Prior to analysis, maize grains were ground in an electric grinder, up to a fine powder. An ethanolic extract made of 10 % grain powder in 70 % ethanol solution was employed in most analyses.

Total carotenoids were calculated by diluting extracts in 80 % acetone and reading spectrophotometric absorbance (ONDA UV-21 spectrophotometer) at 470 nm. Concentrations were calculated according to literature. Concentration (mg/L) was calculated as $1000/198\times A_{470}$ (Popoviciu et al. 2024).

Specific carotenoids were also determined: lycopene, lutein, cryptoxanthin and zeaxanthin. Extracts were diluted in acetone:petroleum ether, petroleum ether, ether, acetone, respectively ethanol and absorbances were read at 445, 446, 453, 505, 645, 663 nm; Concentrations (mg/L) were derived as $0.216\times A_{663}-1.22\times A_{645}-0.304\times A_{505}+0.452\times A_{453}$, for β-carotene, $0.204\times A_{645}-0.0485\times A_{663}+0.372\times A_{505}-0.0806\times A_{453}$, for β-carotene, $0.2129805\times A_{446}$ for lutein, $0.0758\times A453$ for cryptoxanthin and $0.40944\times A_{445}$ for zeaxanthin, according to Braniša et al. (2014), Sujith et al. (2010), Biehler et al. (2009), Butnariu et al. (2014).

Total phenolic compounds were assesed using Folin-Ciocâlteu reaction and absorbance reading at 765 nm against a gallic acid calibration curve, with concentrations calculated as $11.4740537+281.1523463\times A_{765}$ (Popoviciu et al. 2024). Total flavonoids and total phenolic acids (hydroxybenzoic and hydroxycinnamic) were determined by 10-fold dilution in of 8:2 ethanol-hydrochloric acid mixture and then reading the spectrophotometric absorbance of the mixture at 220, 275, 325, 345 and 380 nm. Concentrations were derived according to Paula et al. (2017), for flavonoids as $182\times A_{375}$; that of hydroxybenzoic acids, as $192\times A_{275}-156\times A_{345}$; that of hydroxycinnamic acids, as $129\times A_{325}-78\times A_{380}$. Flavanols (catechins), by dilution in 70 % ethanol and reading at 280 nm; concentration was calculated as $(A_{280}-0.054055)/0.0113$ (Yaneva et al. 2020). Anthocyanins, by dilution in 70 % ethanol and reading at 520 and 700 nm; concentration was calculated as $(A_{520}-A_{700})\times 449.2$ (Braniša et al. 2014).

Tannins were determined after thermal hydrolysis in a mixture of water and hydrochloric acid and reading at 550 nm; concentrations were derived as $19.33\times(A_{550\ hydrolysed}-A_{550\ control})$ (Moutari et al. 2018). Stilbenes, by diluting in 70 % ethanol and reading at 304 nm; calculated as $(A_{304}-0.0697)/0.0704$ (Bancuta et al. 2015). Coumarins, by diluting in 80 % methanol and reading at 275 nm; derived as $(A_{275}-0.03)/0.0771$ (Soares e Silva et al., 2012).

Ascorbic (and dehydroascorbic) acid concentration was determined by diluting in ethanol and reacting with ammonium molybdate and sulfuric acid, followed by absorbance reading at 494 nm; concentration (mg/L) was calculated as $(A_{494}-0.0133)/0.015$ (Riscahyani et al. 2019). Total soluble carbohydrates were determined by reacting extracts with sulfuric acid and phenol (5 %) and reading at 490 nm; calculated as $(A_{490}+0.035)/0.05775$ (Agrawal et al. 2015).

Lipids were determined by extracting grain powder in petroleum ether, filtration, solvent evaporation and gravimetry (Orphanides et al. 2011).

RESULTS AND DISCUSSIONS

The concentrations of various classes of compounds with bioactive potential are shown in Figures 1-2 and Table 1.

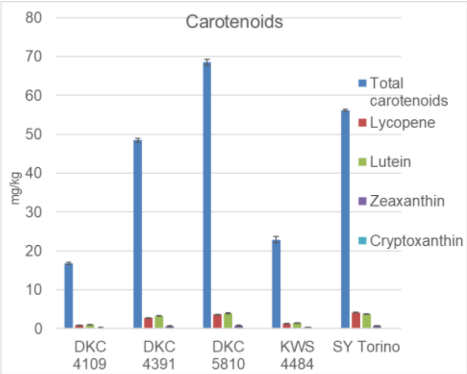

Figure 1. Concentrations of total and some individual carotenoids in corn grains (mg/kg FW).

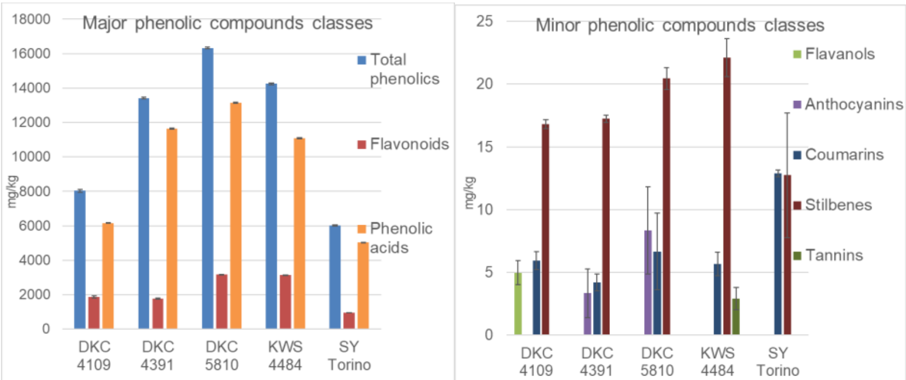

Figure 2. Concentrations of total phenolic compounds and some subclasses in corn grains (mg/kg FW).

The total concentration of carotenoid compounds varied among hybrids (Fig. 1), from 17 mg/kg (DKC 4109) to 69 mg/kg (DKC 5810). Lycopene reached its maximum levels in SY Torino (4.14 mg/kg), followed by DKC 5810, while the latter had the highest amount of lutein (3.99 mg/kg). β-carotene levels were below detection limit. Among xanthins zeaxanthin was dominant, with its highest values in DKC 5810 and SY Torino (over 0.7 mg/kg). Carotenoid compounds often reach around 10 mg/kg in yellow maize varieties (da Cruz et al. 2022), with lutein and xanthins being usually dominant (Bacchetti et al. 2013). A previous study on four hybrids found 10-45 mg/kg (Popoviciu et al. 2024).

Table 1.

Other compound classes in corn grains (mg/kg FW).

	Ascorbic acid	Soluble Sugars	Lipids
DKC 4109	485±18	20,883±538	32,333±385
DKC 4391	522±27	39,134±330	23,333±385
DKC 5810	460±21	26,874±159	22,333±192
KWS 4484	265±7	31,157±191	36,333±385
SY Torino	682±4	25,593±92	22,000±577

The total phenolic concentration also varied, with average values between 6,016 mg/kg (SY Torino) and 16,326 mg/kg (DKC 5810). KWS 4484 also hosted a high amount (14,243 mg/kg). The dominant fraction was that phenolic acids, especially hydroxycinnamic ones, with 5,026-13,132 mg/kg (maximum in DKC 5810; equivalent to 77-87 % of the phenolic inventory). Hydroxybenzoic acids were found in detectable amounts only in DKC 4391 and 5810.

Flavonoid amounts were 965-3,167 mg/kg (maximum in DKC 5810 and KWS 4484; equivalent to 13-23 % of total phenols). Among them, flavanols were only detected in DKC 4109 (below 5 mg/kg), while anthocyanins in DKC 4391 and 5810 (3.34-8.35 mg/kg). Coumarins were 4.19-12.88 mg/kg and stilbenes12.73-22.11 (maximum in KWS 4484). Tannins were only detected in KWS 4484 (2.90 mg/kg). Literature shows that phenolic compounds are a variable constituent of maize grains. Some cultivars have concentrations below 2,000 mg/kg (Zhang et al. 2017; Sinay et al. 2022), while more performant ones surpass 5,000 mg/kg (da Cruz et al. 2022).

Flavonoids are usually a minor fraction, between 5-30 % (Sinay et al. 2022), lower in yellow varieties (Martínez-Martínez et al. 2019). Phenolic acids, are usually the dominant fraction, like in most cereals (they include like protocatechuic, p-hydroxybenzoic, vanillic, syringic, ferulic and caffeic ones; Dykes & Rooney 2007). A previous study on four local hybrids found total phenolic amounts of 7,651-10,622, of which 21-29 % flavonoids and 48-69 % phenolic acids (however, with hydroxybenzoic acids being dominant), higher amounts of coumarins (over 300 mg/kg) and stilbenes (100-126 mg/kg; Popoviciu et al. 2024)

Ascorbic acid (Table 1) ranged between 265-682 mg/kg (maximum in SY Torino). It usually has low concentrations in maize grains, sometimes below 100 mg/kg (Hooda & Kawatra 2013). The amounts found are however higher, even higher than those found by Popoviciu et al. (2024), of 165-219 mg/kg.

Free soluble sugars were 20,883-39,134 mg/kg, minimum in DKC 4109, maximum in KWS 4484. Levels above 50,000 mg/kg are more common (Szymanek et al. 2015), even though they can drop to 20,000 mg/kg (Popoviciu et al. 2024), consisting of glucose, fructose and sucrose (Miya et al. 2018). Lipid oil amounts were 22,000-36,333 mg/kg, highest in KWS 4484.

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CONCLUSIONS

All five selected cultivars were found to have high nutritional properties Carotenoids were 17-69 mg/kg, with notable amounts of lutein and lycopene.

Phenolic inventory was high: 6,016-16,326 mg/kg, of which phenolic acids (especially hydroxycinnamic ones were dominant (77-87 %), followed by flavonoids. Ascorbic acid concentration was also high, between 265-682 mg/kg.

Free soluble sugars were also found in variable amounts, of 20,883-39,134 mg/kg, the same being true for lipid oil, with 22,000-36,333 mg/kg.

DKC 5810 scored highest in terms of total carotenoids, lutein, xanthins, total phenolics, flavonoids, anthocyanins, phenolic acids; KWS 4484 also hosted high amounts of phenolics, also scoring highest in terms of tannins, stilbenes and oils; SY Torino was first in terms of lycopene, coumarins, ascorbic acid (but with the lowest phenolic inventory); DKC 4391 had the highest free sugar amount.

REFERENCES

Agrawal N., Minj D.K., Rani K. 2015. Estimation of total carbohydrate present in dry fruits. IOSR J. Environ. Sci. Toxicol. Food Technol., 1(6), 24-27.

Agro Bayer România. Semințe de porumb, https://www.cropscience.bayer.ro/products/seeds/corn.

Bacchetti T., Masciangelo S., Micheletti A., Ferretti G. 2013. Carotenoids, phenolic compounds and antioxidant capacity of five local Italian corn (*Zea mays* L.) kernels. J. Nutr. Food Sci., 3(6), 1-4, doi: 10.4172/2155-9600.1000237.

Bancuta O.R., Chilian A., Bancuta I., Ion R.M., Setnescu R., Setnescu T., Gheboianu A., Lungulescu M. 2015. FT-IR and UV-VIS characterization of grape extracts used as antioxidants in polymers. Rev. Roum. Chim., 60(5-6), 571-577.

Bayer Crop Science. https://www.cropscience.bayer.ro.

Biehler E., Mayer F., Hoffmann L., Krause E., Bohn T. 2009. Comparison of 3 spectrophotometric methods for carotenoid determination in frequently consumed fruits and vegetables. J. Food Sci., 75(1), C55-61, doi: 10.1111/j.1750-3841.2009.01417.x.

Braniša J., Jenisová Z., Porubská M., Jomová K., Valko M. 2014. Spectrophotometric determination of chlorophylls and carotenoids. An effect of sonication and sample processing. J .Microbiol. Biotech. Food Sci., 3(2), 61-64.

Butnariu M., Rodino S., Petrache P., Negoescu C., Butu M. 2014. Determination and quantification of maize zeaxanthin stability. Dig. J. Nanomater. Biostructures., 9(2), 745-755.

Cristianini M., Sánchez J.S.G. 2020. Extraction of bioactive compounds from purple corn using emerging technologies: A review. Food Sci., 85(4), 862-869, doi: 10.1111/1750-3841.15074.

Da Cruz L.L., Gonçalves L.M.B., Glória L.L., Pereira S.M.F., Carlos L.A., Vivas M., Pereira M.G., de Oliveira D.B. 2022. Phenolic compounds, carotenoids, and antioxidant activity in a super-sweet corn hybrid. Pesq. Agropec. Bras., 57, 1-7, doi: 10.1590/S1678-3921.pab2022.v57.02663.

Dykes L., Rooney L.W. 2007. Phenolic compounds in cereal grains and their ealth benefits. Cereal Foods World, 52(3), 105-111.

Hooda S., Kawatra A. 2013. Nutritional evaluation of baby corn (*Zea mays*). Nutr. Food Sci., 43(1), 68-73, doi: 10.1108/00346651311295932.

Martínez-Martínez R., Vera-Guzmán A.M., Chávez-Servia J.L., Aquino-Bolaños E.N., Carrillo-Rodríguez J.C., Pérez-Herrera A. 2019. Bioactive compounds and antioxidant activities in pigmented maize landraces. Interciencia, 44(9), 549-556.

Miya S.P., Modi A.T., Tesfay S.Z., Mabhaudhi T. 2018. Maize grain soluble sugar and protein contents in response to simulated hail damage. South African Journal of Plant and Soil 35(5), 377-383, doi: 10.1080/02571862.2018.1446222

Moutari S.K., Abdoulkadri A.M., Boulhassane A.S., Rabani A., Khalid I. 2018. Determination contents of total phenolic pigments and spectrophotometric characterization of crude extracts of ten tinctorial plants of Niger which is usable in solar energy. Eur. Sci. J., 14(33), 389-407, doi: 10.19044/esj.2018.v14n33p389.

Navarro A., Torres A., Fernández-Aulis F., Peña C. 2018. Bioactive compounds in pigmented maize. In Amanullah, Fahad S. (eds.), Corn - Production and Human Health in Changing Climate, IntechOpen, London, 69-91, doi: 10.5772/intechopen.78340.

Orphanides A., Goulas V., Chrysostomou M., Gekas V. 2011. Recovery of essential oils from carobs through various extraction methods. In Mastorakis N., Mladenov V., Lepădătescu B., Karimi H.R., Helmis C.G. (eds.), Recent Advances in Environment, Energy Systems and Naval Science, WSEAS Press, Athens, 219-224.

Paula V.B., Estevinho L.M., Dias L.G. 2017. Quantification of three phenolic classes and total phenolic content of propolis extracts using a single UV-vis spectrum. J. Apic. Res., 56(5), 569-580, doi: 10.1080/00218839.2017.1370904.

Popescu M., Ciora M., Bran A., Theodorescu M. 2016. Catalogul oficial al soiurilor de plante de cultură din România. Ediție completă 2016. ISTIS, 168 pp.

Popoviciu D.R., Panaitescu L., Stroe C.T. 2024. Quantitative analysis of nutritional bioactive compounds in some maize cultivars (*Zea mays* L.). Ann. Univ. Craiova, Ser. Biol. Hortic. Food Prod. Process. Environ. Eng., 29(65): 404-409, doi: 10.52846/bihpt.v29i65.170.

Riscahyani N.M., Ekawati E.R., Ngibad K. 2019. Identification of ascorbic acid content in *Carica papaya* L. using iodimetry and UV-Vis spectrophotometry. Indones. J. Med. Lab. Sci. Technol., 1(2): 58-64, doi: 10.33086/ijmlst.v1i2.1291.

Sinay H., Mehulette F., Yáñez J.A. 2022. Determination of free radical scavenging activity, phenolic and flavonoid content of seven corn cultivars from the Southwest Maluku District, Indonesia. Biodiversitas, 23(11), 5974-5981, doi: 10.13057/biodiv/d231151.

Soares e Silva L., Santos da Silva L., Larissa Brumano L., Stringheta P.C., de Oliveira Pinto M.A., Dias L.O.D., de Sá Martins Muller C., Scio E., Fabri R.L., Castro H.C., da Penha Henriques do Amaral M. 2012. Preparation of dry extract of *Mikania glomerata* Sprengel (guaco) and determination of its coumarin levels by spectrophotometry and HPLC-UV. Molecules, 17(9), 10344-54, doi: 10.3390/molecules170910344.

Sujith A.M.A., Hymavathi T.V., Devi P.Y. 2010. Supercritical fluid extraction of lutein esters from marigold flowers and their hydrolysis by improved saponification and enzyme biocatalysis. Int. J. Nutr. Food Eng., 4(1), 74-83, doi: 10.5281/zenodo.1331475.

Syngenta. https://www.syngenta.ro.

Szymanek M., Tanaś W., Kassar F.H. 2015. Kernel carbohydrates concentration in sugary-1, sugary enhanced and shrunken sweet corn kernels. Agriculture and Agricultural Science Procedia, 7(1), 260-264, doi: 10.1016/j.aaspro.2015.12.044.

Yaneva Z., Ivanova D., Beev G., Besheva K. 2020. Quantification of catechin in *Acacia catechu* extract by non-derivative, first derivative UV/Vis spectrophotometry and FT-IR spectroscopy. Bulg. Chem. Commun., 52, 41-47.

Zhang R., Huang L., Deng Y., Chi J., Zhang Y., Wei Z., Zhang M. 2017. Phenolic content and antioxidant activity of eight representative sweet corn varieties grown in South China. Int. J. Food Prop., 20(12), 3043-3055, doi: 10.1080/10942912.2016.1270964.