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CONTENTS

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ADVANCING THE NEW RESEARCH PATHWAYS OF "NUTRIBREEDING" FOR HUMAN AND ANIMAL NUTRITION WITH HEALTH BENEFITS

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Abstract: New pathways in grain breeding and the cultivation of nutritionally enriched crops are imposed by the world's population expansion and trends in food and feed production, which encourage the use of functional foods with potential health benefits. A sustainable turnkey system that produces high-quality, nutritionally rich crops may be achieved by a new generation of genotypes of cereals and legumes, such as soybean and maize, that have optimal physical and chemical properties along with higher antioxidant levels due to the presence of polyphenols and anthocyanins. Generating the new research avenue called "nutribreeding" is part of the CREDIT Vibes project funded by the European Commission.

Keywords: grains, breeding, food and feed, nutrients, health benefits

Introduction

Maize (*Zea mays* L.) stands as one of the most important cereal crops for utilization as a raw material for food, feed, energy, and industrial applications. Data from Statista (Shahbandeh, 2024) indicate that over the 2023–2024 timeframe, about 1.235,73 million metric tons of maize were produced worldwide. With 388.01 million metric tons produced globally over the 2023–2024 period, soya bean (*Glycine max*) is the most extensively used legume (Shahbandeh, 2024). Despite being a major food crop, maize has seen a sharp growth in demand over the past twenty years for livestock feed. This was mostly brought on by the swift economic growth in highly populated regions of Asia, the Middle East, and South America, which raised the demand for food products made from chicken and cattle among affluent consumers (Shiferaw *et al*., 2011; Delgado 2003). Interest in functional soy products has been on the rise in recent years. The reason for this is the nutritional composition and properties that can favorably affect cardiovascular diseases and the overall health of consumers. The soybean, in addition to being rich in protein, has a low content of saturated fat and does not contain cholesterol.

According to Cederroth and Nef (2009) and Barać *et al*. (2014), soybeans are made up of macronutrients like proteins, lipids, and carbohydrates, micronutrients like vitamins and minerals, and phytochemicals such as phytosterols, tocopherols, carotenoids, and phenolic compounds. Because soy products offer high-quality proteins, few saturated fats, and no cholesterol, they are becoming an increasingly essential source of protein in the human diet and have functional, nutritional, and even health benefits for those with cardiovascular illnesses and general health (Tang, 2019).

Due in large part to the excellent antioxidant activity of the already existent bioactive chemicals in colored grains, interest in their utilization in the food sector has grown. The color of maize grains varies greatly genetically. There are types of maize that are black, blue, purple, pink, red, orange, green, and brown (Žilić et al., 2023). The color difference between black, brown, and yellow (standard) soybeans is caused by the presence of proanthocyanidins and anthocyanins in the seed coat's epidermal layer (Žilić et al., 2013). In Korea, China, and Japan, black soybeans have been regularly used for millennia as a medicinal plant (Xu and Chang, 2008).

The three guidelines of the concept of CREDIT Vibes are nutrient-rich food and feed, a safer, eco-friendly environment, and a healthy existence on an ecologically sound planet. Creating an inventory of genetic resources available for each crop species and defining a working collection of nutricrops are among the key objectives of the project. As a part of the project, colored maize and soybean genotypes with good nutritional and bioactive properties were analyzed to identify the most promising hybrids/varieties presently popular in conventional production, for further research.

This paper tends to showcase some of the recently obtained results on the chemical composition and bioactive properties of the selected maize and soybean genotypes. These represent a promising starting material for further research on the development of nutritionally rich grains for food and feed production.

Materials and methods

The plant material used in this study encompasses three maize and three soybean genotypes created and grown in the experimental plots of the Maize Research Institute, Zemun Polje, Belgrade, Serbia (44°52′N, 20°19′E, 81m asl). The maize grains and soybeans were ground in a laboratory mill (Perten Mill 120 CE; Perten Instruments, Hägersten, Sweden) and a mill with a cooling chamber (Knifetec 1095 Sample Mill, Foss Tecator, Höganäs, Sweden), respectively. The Kjeldahl (AOAC, 1990) and Ewers (ISO 10520:1997) methods were applied to determine the protein and starch content, respectively. The oil content was analyzed according to the Soxhlet method (AOAC, 2000). The Van Soest detergent method modified by Mertens (1992) was used to determine the share of lignocellulosic fractions. The antioxidant capacity of the maize and soybean flour was measured by the direct or QUENCHER method using the ABTS (Serpen *et al.*, 2008). Absorbance was measured at 734 nm (Agilent 8453 spectrophotometer; Agilent Technologies, Inc.), and total antioxidant capacity was expressed in mmol Trolox equivalents per kg of dry mass. Determination of total yellow pigment content was performed according to the reference method AACC (1995) 14-50. All analyses were done in two replicates. The results are shown as averages.

Results and discussion

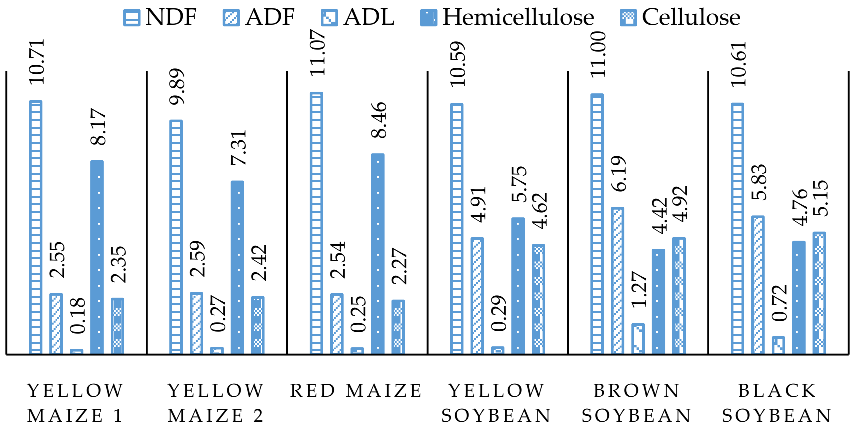
The chemical properties of the investigated maize and soybeans samples are shown in Table 1.

Table 1. Chemical properties of maize and soybean grains (%)

Genotype	Starch	Protein	Oil	Ash
Yellow maize 1	70.32	10.45	5.32	1.56
Yellow maize 2	73.76	10.38	4.85	1.24
Red maize	70.23	11.27	5.27	1.42
Yellow soybean	N. D.	41.15	21.76	5.23
Brown soybean	N. D.	37.45	21.59	5.46
Black soybean	N. D.	42.27	22.44	5.42

The starch content of the maize samples ranged from 70.23% (Red maize) to 73.76% (Yellow maize 2), while the protein content of the soybean genotypes ranged from 37.45% (Brown soybean) to 42.27% (Black soybean).

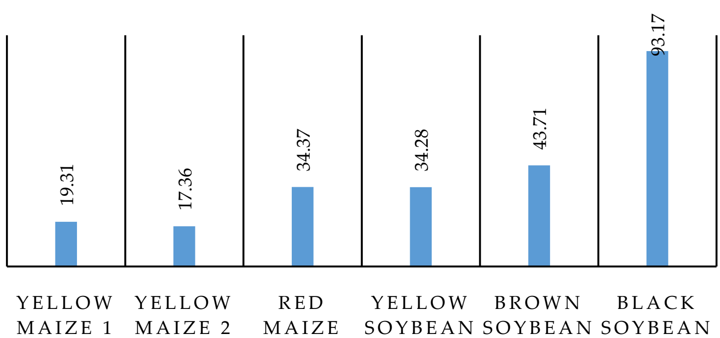
Graph 1 shows the results of analyses of the content of individual lignocellulosic fibers in the tested samples.



Graph 1. Lignocelullosic fibers content (% d.m.)

The genotypes manifested a variation of different lignocellulosic contents, which makes them suitable for different nutritional and industrial applications. (Graph 1). The fiber content in maize and soybeans is one of the important parameters of their nutritional quality. Dietary fiber has become an important ingredient in the modern diet thanks to its beneficial effects on health, such as lowering cholesterol, modifying the glycemic response, lowering insulinemia, improving bowel function, as well as antioxidant properties.

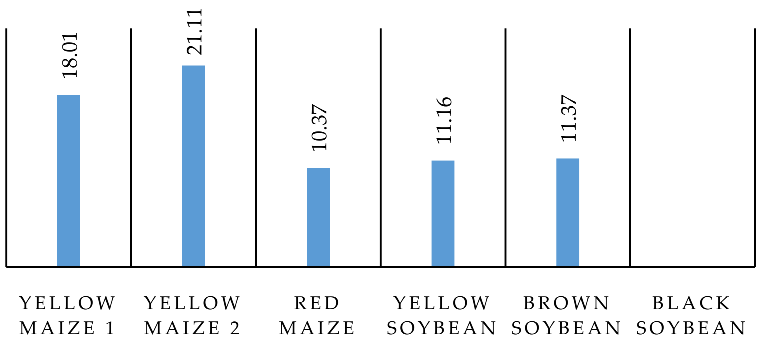
The detected antioxidant capacity of the investigated samples is shown in Graph 2.



Graph 2. Antioxidant capacity (mmol Trolox kg^{-1} d.m.)

The high antioxidant capacity of the black soybean genotype can be attributed to the concentrations of 3-O-glucoside anthocyanins, such as cyanidin, delphinidin, and pelargonidin, make up their seed coat, as previously reported by Žilić et al., 2019. Recent research has demonstrated that dietary fiber and polyphenols from the soybean seed coat can be utilized as bioactive components in pharmaceutical and functional food products targeted at various health issues (Žilić et al., 2020).

The total yellow pigment of the investigated samples was the highest in yellow maize genotype number 2 (21.11 μg βCE g-1 d.m.), while in the black soybean genotype, it was not detected (Graph 3).



Graph 3. Total yellow pigment (μg βCE g^{-1} d.m.)

Conclusion

The maize and soybean genotypes investigated in this study have shown favorable chemical composition and antioxidant properties suitable for different purposes such as the production of nutritious food and feed. They will be used for further research.

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