Hop and Medicinal Plants, Year XXX, No. 1-2, 2022
ISSN 2360 – 0179 print, ISSN 2360 – 0187 electronic

Potato as a Complex Plant with Medical Benefits

BERINDEAN Ioana Virginia, Andreea D. ONA, Camelia MUNTEANU, Ionuț RACZ, Bianca POP, Alexandru D. COSTIN*
University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca,
Faculty of Agriculture, Department of Crop Science, Genetics
3-5 Calea Mănăștur, 400372, Cluj-Napoca, Romania
*Correspondence: dan_alexandru05@yahoo.com

Abstract: Although the ”potato’s journey” from its discovery to its introduction into culture took a long time and was skeptical, but now it is ultimately one of the largest crops worldwide. Also being an accessible food and due to the complex of nutrients found in the tubers, are considered both nutritional and medical qualities. Currently, various studies are found in the literature confirming the role and importance of using potatoes in different medical treatments or to improve the health of people. These results and recommendations are based on potato composition rich in phytonutrients, antioxidants, minerals and vitamins by baked or boiled, using also the flesh and the peel. It has been proven that many of the essential components are found in potato peel at a much higher concentration than in the flesh. Also, the peel resulting from the peeling tubers is used in animal feed, but can be used as a solid substrate in various processes (fermentation or the powder as gluten-free flour). In traditional medicine, raw potato are usually used for different treatments like gastrointestinal disorder, gastroduodenal diseases, to reduce fever and hot topical pack are used for pain or for softening furuncles. Potato juice protein concentrate (PJPC) was used to observe its selective activity on different type of cancer cell line.

Keywords: antioxidants, medical uses, phytonutrients, potato, *Solanum tuberosum*, vitamin.

Introduction

A short history about the potato

Solanum tuberosum L., the well-known potato, has an ancient and glorious history to match its nutritional qualities. Although originally from South America, on the slopes and sunny valleys of the Andes mountains (Vlachojannis et al., 2010a), and the surroundings of Lake Titicaca, it was "found" by Europeans in 1492 and "discovered" only in 1532, after the Spanish conquest of Peru. In Europe, it was treated with hostility because it was thought to produce leprosy, to change the blue colour of noble blood, to be food sent from hell (Ley, 1968). Moreover, some believed that tubers were poisonous or generating diseases such as diarrhea, scrofulosis or other diseases, like „stupid", because the first potato has sour flavour. Parmentier was the most devoted character on the history of this plant, rightly called "the father of the introduction and spread of the potato in Europe", he perfected the methods of showing and multiplied the species (Morar, 1999). Also, famines from the early 1770's contributed to its acceptance, as did government policies in several European countries (Abel, 2005).

The potato entered in Romania at the end of the 18th century. The first writings appeared in Transylvania, more exactly in a report on the Blaj printing house, in 1972, mentions the first practical guidance manuals, entitled "Practical instructions for potato culture", and also its expansion in culture is due to the famine during the reigns of Constantin Mavrocordat (1819) and Caragea Voda (1821 – Wallachia) (Plămădeală, 1996).

For many times the potato is considered a banality plant, but in reality, it was a revolution in industry and also in science for plant cultivation, because the potato is the plant that nurtured and sustained for many millennia a civilization and culture of the Indians of Central and South America. For potato, the road to conquering the world was hard and took quite a while, but in the end, it has defeated and now dominates the world, becoming a staple food for almost all of humanity around the globe, competing with the most important food sources, such as: cereals, fruits and meat.

The advantages of the potato are its high yield potential in a short growth time, the high edible dry matter content of its tubers, and its high dietary value as a staple food, so it became food for humans and also for animals (Spooner, 2013). In the human body, the nourishing substances in the potato are converted into energy faster than those in meat or fat (Bodea et al., 2002). In addition to the high content of carbon hydrates, the potato provides a high amount of energy, proteins and vitamins, in specially vitamin C. For example, an average size raw potato contain 115 calories, 3.2 g of protein, 30 mg of vitamin C and 80 mg of phosphorus, but when is boiled it loses some of vitamin C (Spooner, 2013). Even if these values are low, nutritional quality of potato is better than cereals and is important to know that the potato has potential to produce more calories and protein per unit land area with less time and water (Reddy et al., 2018), as PARMANTIER recommend, after the introduction of the potato into the culture (1789), ”this culture is founded on only one principle, production is always proportional to the care given to it” (Oprea, 1997).

Potatoes, especially their pulp, being a rich source of key micronutrients (vitamin C, potassium, magnesium), fiber and phytochemicals (phenolic and carotenoids), so they have become a global culture being used and transformed into many products with impact on human health, from under-nutrition, disease prevention, to over-nutrition, such as obesity, diabetes, cardiovascular disease (Furrer et al., 2018). Even if not consumed constrict, potato peel provides substantial dietary fiber, so many compounds in potatoes contribute to the antioxidant activity of the body. In many regions of the world potatoes are usually eaten cooked, and most often eaten boiled and unpeeled (Camire et al., 2009)

Many studies confirm the nutritional quality of the potato and its medicinal effect on health. The beneficial components found in potato tubers and their beneficial effects extracted from various studies on human health are presented in this short review.

Potato nutrition and composition

One potato tuber (100 g) had in its composition 80% water and 20% solids. In this 20 g of solid are found 18 g carbohydrates and 2 g of protein. Also, has a low calorie because a small quantity of sugar, but potassium, vitamin C and vitamin B6 are the most abundant nutrients in potatoes. Polyphenols had a big contribution to the diet and. Different phytonutrients are accumulate in tuber peel or flesh, phenolic compounds are present in higher concentrations in the tuber peel than in the flesh (Navarre et al., 2019).

Protein

Potato tuber proteins are mainly grouped into three categories, i.e. patatins (which is a major storage protein), protease inhibitors (together with patatins account for 40% of total potato tuber protein) and other proteins, like lysine (Mishra et al., 2020). While potatoes contain small amounts of protein, the protein they do contain has a high biological value (BV) with a BV of 90 to 100 compared with whole egg (BV 100), soybean (BV 84), and beans (BV 73) (McGill et al., 2013). Potato proteins are nutritionally comparable to whole egg protein and are a rich source of lysine. Due to this reason, compared to cereal proteins, potato protein is of high quality, and also due to its higher methionine content, is better than protein from peas and beans. Several investigators place potato protein on an equal nutritive basis with animal protein (Rexen, 1976). Owing to their antifungal behaviour and functional stability at high temperature, research carried out by Bártová et al. (2018), potato protease inhibitors I and II could find a potential role in agriculture, food or pharma.

Minerals

Minerals are recommended by nutrition professionals to be consumed as part of a balanced diet (Bethke and Jansky, 2008). Minerals play an essential role in sustaining various physiological and metabolic processes occurring within living tissues, as enzymes structure and function, bone and blood maintenance, immune responses or transmission of nerve impulses (Silva et al., 2019). The minerals can be found primarily in fruits and vegetables and can be easily consumed rather than in the form of dietary supplements.

Potatoes are a valuable source of mineral nutrients, provide phosphorus, magnesium, and iron; and are very low in sodium (McGill et al., 2013). Regarding to the content of minerals (in mg), in potato prepared by common methods, in 100 g of potato the quantity of calcium, iron, magnesium and potassium is higher in the baked tuber (flesh with skin), then boiled (flash only), but the quantity of phosphorus, sodium and zinc is higher when the potato is prepared as French fries, frozen and oven heated (McGill et al., 2013). (Navarre et al., 2019) reviewed the daily recommended values for potassium (4700 mg/day) and magnesium (310 to 420 mg/day) in different potato cultivars. The potato is not a rich source of either calcium or magnesium in the human diet, but genetic variation exists among potato clones that might be useful for plant health (Brown et al., 2012). Iron and zinc deficiency in the humans occurs in all regions of the world, but potatoes are considered a modest source of iron and zinc (Brown et al., 2010; 2011). On the other hand the quantities of minerals in potato depend by cultivars, but also by the method adopted for cultivation and atmospheric and geographical conditions of the region where the crop is grown, play an important role in mineral accumulation in potato tubers (Nassar et al., 2012; Lombardo et al., 2014). The author made an evaluation of the mineral profile of three ”early” potato cultivars (Arinda, Ditta, Nicola) both organically and conventionally produced over two consecutive seasons. The results show as that organically cultivated tubers contained more phosphorus, magnesium and cooper then the conventionally grown ones, but lower calcium, iron, sodium, potassium and manganese levels.

Vitamins

The potato contains several water-soluble vitamins such as C, B9, B5, B2, B6, and B1 (Camire et al., 2009). Its tubers are more rich in starch and vitamin C then provitamin A and vitamin E (Chitchumroonchokchai et al., 2017). Interestingly, the content of vitamin C (VC) in raw potatoes is high (143 g is 27 mg). Regarding the recommended dietary allowance (RDA), this content is found to be approximately 30-40% for both women and men (Beals, 2019). Of course, the vitamin C content can be affected by the treatment that the potatoes undergo, freezing, steam, cooking methods, and last but not least, sulphite treatment (Sun et al., 2020). Also, there is a difference in the vitamin C concentration from potatoes between organically and conventionally grown plants (Rembiałkowska, 2007).

In humans, this vitamin is considered essential, recognized as an essential antioxidant and the body is not able to synthesize it (De Tullio, 2010). In addition, it is involved in intermediary steps of certain metabolic pathways such as the biosynthesis of tyrosine and the amidation of different peptide hormones (Hellmann et al., 2021). As previously seen, contrary to the negative advertising, especially because of the fried ones, potatoes are an important and very accessible source of Vitamin C for consumers (Navarre et al., 2019).

Also, the fat-soluble vitamin E is present in potatoes (Chaparro et al., 2018) and it is considered one of the most powerful antioxidative agents that can be used by humans and which can only be synthesized by photosynthetic organisms (Crowell et al., 2008). Also named *tocopherol*, is a type of vitamin that can help plant oil bodies absorb and store fats. Two major groups of vitamin E in plants are, tocotrienol and tocopherol, which both have antioxidative properties (Ahmed et al., 2020; Konda et al., 2020; Pellaud et al., 2018; Noreen et al., 2021; Rodríguez et al., 2021). A vital component of human nutrition is α-tocopherol and is commonly found in potatoes (Monsen et al., 2000). It is known that the vitamin can be preferentially stored in the tubers over the other vitaE isomers (Chun et al., 2006). The content can vary depending on the variety and colour (Chaparro et al., 2018). In potatoes, the level of α-tocopherol has been estimated to be between 68 and 517.5 g/100 g FW in raw tuber samples from the Andean genotypes. On the other hand, the commercial varieties have varying amounts ranging from 15 to 75 g/100 g FW, recalculated by Andre et al. (2007).

The daily consumption of potato makes it a key target for biofortification with vitamins for eliminating vitamin deficiency in large populations. Vitamin E biosynthetic pathway genes have been overexpressed in plants via genetic engineering to enhance the α-tocopherol content.

Group of vitamin B has many functions in the body, like maintaining a healthy skin and nervous system, or is essential components in the metabolism of carbohydrates to offer energy. Folic acid is needed for cell growth and development. Potato offer, also, different group of vitamins B and folate (Das et al., 2017), and also is a good source for potassium (McGill et al., 2013). This author recommends as for consumption oven-heated French fries' potato because they are a good source of vitamin C and potassium and provide vitamin B6, folate, riboflavin, thiamin, phosphorus, magnesium, and iron.

Regardless of the method used to prepare potatoes e.g., boiled, oven-baked or microwave-cooked and if is peel or flesh. They contain approximate the same amount of ascorbic acid (between 6.7 mg/100 g in the peel of boiled tuber and 12.6 mg/100 g in the flesh when is prepared in the microwave), higher amounts of folic acid it was found in the peel (19.7 ug/100 g) and 12.3 ug/100 g in the flesh of tuber oven-baked, more than in the boiled and microwave-cooked tuber. The quantities of vitamin B6 are higher in peel oven-baked tuber (0.42 mg/100 g) and in the microwave-cooked (0.26 mg/100 g). In boiled-unpeeled tuber is 0.24 mg (in the flesh) and 0.18 mg/100 g (in the peel). The quantities of nutrients are found in raw tuber: 14.4

mg/100 g ascorbic acid (in flesh), 17.3 ug/100 g folic acid (in the peel) and 0.22 mg/100 g vitamin B6 (in the peel) (Augustin et al., 1979).

Usually the processing of potato tuber involves peeling and that peel is used in animal feed or discarded (Sampaio et al., 2020), but the raw peel area contained significantly higher amounts of total ash, crude fiber, protein and riboflavin and folic acid than the corresponding flesh (Augustin et al., 1979) and can be used as a potato peel powder which could serve as a partial flour replacement in dough up to 10 g 100 g^{-1} of flour weight or as a solid substrate for fermentation (Sepelev and Galoburda, 2015).

Antioxidants

Antioxidants are substances with an important role in reducing the cellular degradation process, caused by the free radical effects (Kalita and Jayanty, 2014). Potato it's an important sources of antioxidants, these substances helping to minimize cellular and tissue toxicity (Rasheed et al., 2022). Antioxidant activities differ in potatoes according to colour, where purple potato tubers have been found to have a higher level of antioxidant properties compared to others (Yang et al., 2016). Antioxidants in the potatoes like vitamins, carotenoids, polyphenols, ascorbic acid and other important substances, they are mostly hydrophilic (Rasheed et al., 2022).

Polyphenols

Polyphenols are secondary metabolites that can be found in plants, their structure being based on an aromatic ring which contain one or more hydroxyl substituents (Beckman, 2000; Parr and Bolwell, 2000). They can be grouped according to chemical structure into phenolic acids, anthocyanins and flavonoids (Ignat et al., 2011) (Lemos et al., 2015). Their presence influences the products quality, including texture, colour and taste (Alasalvar et al., 2001; Rytel et al., 2014). In comparison to other common fruits and vegetables like carrots, tomatoes, or onions, potatoes have a higher overall polyphenolic concentration, making them a good source of polyphenolic compounds (Chun et al., 2005).

Phenolic acids

Plants primarily include substituted derivatives of hydroxybenzoic and hydroxycinnamic acids as phenolic acids (Akyol et al., 2016). The most phenolic compounds found in potatoes are phenolic acids (Farvin et al., 2012; Mäder et al., 2009; Singh and Saldaña, 2011). Chlorogenic acid, the ester of quinic and caffeic acid, has been described in potatoes (Al-Weshahy and Rao, 2009; Amado et al., 2014).

Anthocyanins

Anthocyanins are additional phenolic molecules which influence potato tuber colour (Rasheed et al., 2022). Anthocyanins contains in coloured tubers mostly petunidin and pelargonidin (Valiñas et al., 2017). Due to their positively charged oxygen atom, anthocyanins have significant antioxidant activity; however, this is also controlled by the hydroxyl number from the B-ring, with pelargonidin having the lowest antioxidant activity and delphinidin having the most (Liu et al., 2018).

Flavonoids

Flavonoids are the most common phenolic compounds found in plants, influencing the colour and flavour of vegetables and fruits. Also the flavones, flavanones, flavonols, isoflavones and anthocyanidins, are the six flavonoids significant subclasses (Akyol et al., 2016). Frequently flavonoids are attached to sugars, but sometimes they can be found as aglycones (Andre et al., 2007). Potatoes contain flavonoids such as quercetin, catechin, rutin and kaempferol-rutinose (Akyol et al., 2016). The flavonoid concentration is higher in purple and red-fleshed potato cultivars than in white-fleshed potato cultivars (Hamouz et al., 2008).

Carotenoids

Carotenoids influence tuber scent and flavour and help potato plants to resist oxidative stress (Cazzonelli and Pogson, 2010). Orange and yellow-flesh potatoes have the highest amounts of carotenoids (Hellmann et al., 2021). Carotenoids include medicinal properties such as immune system stimulation, anti-inflammatory activity, decreased risk of cardiovascular disease, diabetes, cancer and anti-depressive activity (Chucair et al., 2007; Abdel-Aal et al., 2013; Lin and Shen, 2021). Lutein and zeaxanthin are important for eye health by reducing the risk of age-related macular degeneration (Chucair et al., 2007; Tan et al., 2008).

Uses of potato for medical treatments

Potential role in improving human health is attributed to presence of wide range of phytonutrients, polyphenols, anthocyanins, carotenoids, ascorbic acid and proteins, vitamins as well as minerals.

Among the most important nutritional values of the potato is the improvement of gastrointestinal health, either directly by modulating the intestinal microbiota (Bibi et al., 2019), respectively strengthening the function of the intestinal epithelial barrier, or indirectly by manipulating secondary metabolites such as short-chain fatty acids produced by polyphenols and degradation of photonutrients. Also, potato consumption improves gut microbial ecology.

In Europe raw potatoes are used in traditional medicine for different gastrointestinal disorder or gastroduodenal disease, also a topical potato protein mixture may be used in the treatment of protease-induced skin inflammations and topical potato preparation (as a hot pack) can be used for pain or for softening furuncles (Vlachojannis et al., 2010b). Also the fever is treated by placing sliced potatoes in the socks, and warming the feet (Smitherman et al., 2005).

Vitamin C is considered to have a health benefit for cardiovascular diseases (CVD) (Joshipura et al., 2001), cataracts that occur in old age, and common colds (Sasazuki et al., 2006).

The FDA has approved a health claim on eating foods that are good sources of potassium (K), such as potatoes, because of the reduced risk of high blood pressure and stroke (McGill et al., 2013). On the other hand, is recommend that patients with kidney disease are advised to moderate their intake of K because increase the chance of nerve damage in legs and feet. For these people, a way to reduce K content from potato tuber is boil them small pieces or leaching cut its in water prior to cooking (Bethke and Jansky, 2008).

Robert et al. (2008), investigated the effect of diet on lipid metabolism and antioxidant status in rats., following the diets containing carbohydrates and antioxidants from potato, complex carbohydrates (starch) and a simple carbohydrate (sucrose) and the results suggest that consumption of complex carbohydrates (provided as cooked potatoes) may enhance the antioxidant defences and improve lipid metabolism.

Rats fed with purified diets containing rice, potato, soybean protein, had serum total cholesterol concentrations lower and fecal bile acid plus neutral steroid excretion significantly higher, compare with those fed with casein (Morita et al., 1997).

Kowalczewski and his team (Kowalczewski et al., 2019), obtained potato juice protein concentrate (PJPC), which is recognised as one of the most valuable nonanimal protein because had a high content of essential amino acids (lysine, thereonine and leucine which it limiting amino acid), substantial amount of Fe, Mn, K and Cu, and also is characterized by higher antioxidant potential. The PJPC was used to observe its selective activity on different type of cancer cell line (gastric cancer cell line - Hs 746T, colon cancer cell line – HT29 and human colon normal cells CCD 841 CoN) and the results revealed differences in the potency of cytotoxicity of PJPC against normal (CCD 841 CoN) and cancerous (HT-29) colon cells. The same opinion have Mishra et al. (2020), which considered that anthocyanins and phenolics of potato are well documented for cytotoxicity in cancer cell lines.

Potatoes, including oven-baked fries and French fries, it was used, with good results, in diets of children, adolescents, and adults (Freedman and Keast, 2012). But McGill et al. (2013) recommend as that scientific literature should be interpreted with prudence since the utilization of potato in food as a diet pattern is dependent on other food which are grouped with him.

Conclusions

There are currently numerous studies attesting the importance of using potato tubers both in various nutritional diets and in various medical treatments.

If potatoes are consumption with peel can bring extra nutritional benefits because the content in nutrients and fiber is higher than in their flesh. It is said that a meal that has potatoes in the menu contributes to satiety. Also, studies of great interest are those in which proteins extracted from tubers, or the use of raw potato juice are considered anti-tumour agents in different cancer cell line, or in treatments to reduce cholesterol or blood pressure regulation.

In conclusion the actual research about of phytonutrients from potato, in particularly proteins, vitamins, minerals, antioxidants and their use for the benefit of human health is of great relevance.

References

Abdel-Aal E.S.M., Akhtar H., Zaheer K. and Ali R., 2013, Dietary Sources of Lutein and Zeaxanthin Carotenoids and Their Role in Eye Health, Nutrients, 5(4):1169–1185. https://doi.org/10.3390/nu5041169.

Abel W., 2005, Agricultural Fluctuations in Europe: From the Thirteenth to the Twentieth Centuries, Taylor and Francis.

Ahmed I.A.M., Matthäus B., Özcan M.M., Juhaimi F.A., Ghafoor K., Babiker E.E., Osman M.A. and Alqah H.A.S., 2020, Determination of Bioactive Lipid and Antioxidant Activity of Onobrychis, Pimpinella, Trifolium, and Phleum spp. Seed and Oils, J Oleo Sci, 69(11):1367–1371. https://doi.org/10.5650/jos.ess20153.

Akyol H., Riciputi Y., Capanoglu E., Caboni M.F. and Verardo V., 2016, Phenolic Compounds in the Potato and Its Byproducts: An Overview, IJMS 17(6):835. https://doi.org/10.3390/ijms17060835.

Alasalvar C., Grigor J.M., Zhang D., Quantick P.C. and Shahidi F., 2001, Comparison of Volatiles, Phenolics, Sugars, Antioxidant Vitamins, and Sensory Quality of Different Colored Carrot Varieties, J Agric Food Chem, 49(3):1410–1416. https://doi.org/10.1021/jf000595h.

Al-Weshahy A. and Rao A.V., 2009, Isolation and characterization of functional components from peel samples of six potatoes varieties growing in Ontario, Food Research International, 42(2):1062–1066. https://doi.org/10.1016/j.foodres.2009.05.011.

Amado I.R., Franco D., Sánchez M., Zapata C. and Vázquez J.A., 2014, Optimisation of antioxidant extraction from *Solanum tuberosum* potato peel waste by surface response methodology, Food Chemistry, 165:290–299. https://doi.org/10.1016/j.foodchem.2014.05.103.

Andre C.M., Ghislain M., Bertin P., Oufir M., del Rosario Herrera M., Hoffmann L., Hausman J.F., Larondelle Y. and Evers D., 2007, Andean Potato Cultivars (*Solanum tuberosum* L.) as a Source of Antioxidant and Mineral Micronutrients, J Agric Food Chem, 55(2):366–378. https://doi.org/10.1021/jf062740i.

Augustin J., Toma R.B., True R.H., Shaw R.L., Teitzel C., Johnson S.R. and Orr P., 1979, Compositon of raw and cooked potato peel and flesh: proximate and vitamin composition, J Food Science, 44(3):805–806. https://doi.org/10.1111/j.1365-2621.1979.tb08506.x.

Bártová V., Bárta J., Vlačihová A., Šedo O., Zdráhal Z., Konečná H., Stupková A. and Švajner J., 2018, Proteomic characterization and antifungal activity of potato tuber proteins isolated from starch production waste under different temperature regimes, Appl Microbiol Biotechnol, 102(24):10551–10560. https://doi.org/10.1007/s00253-018-9373-y

Beals K.A., 2019, Potatoes, nutrition and health, American Journal of Potato Research, 96(2):102-110.

Beckman C.H., 2000, Phenolic-storing cells: keys to programmed cell death and periderm formation in wilt disease resistance and in general defence responses in plants? Physiological and Molecular Plant Pathology, 57(3):101–110. https://doi.org/10.1006/pmpp.2000.0287.

Bethke P.C. and Jansky S.H., 2008, The Effects of Boiling and Leaching on the Content of Potassium and Other Minerals in Potatoes, Journal of Food Science, 73(5):H80–H85. https://doi.org/10.1111/j.1750-3841.2008.00782.x.

Bibi S., Navarre D.A., Sun X., Du M., Rasco B. and Zhu M.J., 2019, Beneficial Effect of Potato Consumption on Gut Microbiota and Intestinal Epithelial Health, Am J Potato Res, 96(2):170–176. https://doi.org/10.1007/s12230-018-09706-3.

Bodea D., Gontariu I., Scurtu D., Brudea V. and Ciobanu V., 2002, Tehnologia culturii cartofului în conditiile din Nordul Moldovei, Editura Suceava.

Brown C.R., Haynes K.G., Moore M., Pavek M.J., Hane D.C., Love S.L., Novy R.G. and Miller J.C., 2012, Stability and Broad-Sense Heritability of Mineral Content in Potato: Calcium and Magnesium, Am J Pot Res, 89(4):255–261. https://doi.org/10.1007/s12230-012-9240-9.

Brown C.R., Haynes K.G., Moore M., Pavek M.J., Hane D.C., Love S.L., Novy R.G. and Miller J.C., 2011, Stability and Broad-sense Heritability of Mineral Content in Potato: Zinc, Am J Pot Res, 88(3):238–244. https://doi.org/10.1007/s12230-011-9188-1.

Brown C.R., Haynes K.G., Moore M., Pavek M.J., Hane D.C., Love S.L., Novy R.G. and Miller J.C., 2010, Stability and Broad-Sense Heritability of Mineral Content in Potato: Iron, Am J Pot Res, 87(4):390–396. https://doi.org/10.1007/s12230-010-9145-4.

Camire M.E., Kubow S. and Donnelly D.J., 2009, Potatoes and Human Health, Critical Reviews in Food Science and Nutrition, 49(10):823–840. https://doi.org/10.1080/10408390903041996.

Cazzonelli C.I. and Pogson B.J., 2010, Source to sink: regulation of carotenoid biosynthesis in plants, Trends in Plant Science, 15(5):266–274. https://doi.org/10.1016/j.tplants.2010.02.003.

Chaparro J.M., Holm D.G., Broeckling C.D., Prenni J.E. and Heuberger A.L., 2018, Metabolomics and Ionomics of Potato Tuber Reveals an Influence of

Cultivar and Market Class on Human Nutrients and Bioactive Compounds, Front Nutr, 5:36. https://doi.org/10.3389/fnut.2018.00036.

Chitchumroonchokchai C., Diretto G., Parisi B., Giuliano G. and Failla M.L., 2017, Potential of golden potatoes to improve vitamin A and vitamin E status in developing countries, PLoS One, 12(11):e0187102. https://doi.org/10.1371/journal.pone.0187102.

Chucair A.J., Rotstein N.P., SanGiovanni J.P., During A., Chew E.Y. and Politi L.E., 2007, Lutein and Zeaxanthin Protect Photoreceptors from Apoptosis Induced by Oxidative Stress: Relation with Docosahexaenoic Acid, Invest Ophthalmol Vis Sci, 48(11):5168-5177. https://doi.org/10.1167/iovs.07-0037.

Chun J., Lee J., Ye L., Exler J. and Eitenmiller R.R., 2006, Tocopherol and tocotrienol contents of raw and processed fruits and vegetables in the United States diet, Journal of Food Composition and Analysis, 19(2-3):196–204. https://doi.org/10.1016/j.jfca.2005.08.001.

Chun, O.K., Kim D.O., Smith N., Schroeder D., Han J.T. and Lee C.Y., 2005, Daily consumption of phenolics and total antioxidant capacity from fruit and vegetables in the American diet, J Sci Food Agric, 85(10):1715–1724. https://doi.org/10.1002/jsfa.2176.

Crowell E.F., McGrath J.M. and Douches D.S., 2008, Accumulation of vitamin E in potato (*Solanum tuberosum*) tubers, Transgenic Res, 17(2):205–217. https://doi.org/10.1007/s11248-007-9091-1.

Das K., Krishna P., Sarkar A., Ilangovan S.S. and Sen S., 2017, A review on pharmacological properties of *Solanum tuberosum*, Research Journal of Pharmacy and Technology, 10(5):1517-1522. https://doi.org/10.5958/0974-360X.2017.00267.0.

De Tullio M.C., 2010, The mystery of vitamin C, Nat Educ, 3(9):48.

Kalita D. and Jayanty S.S., 2014, Comparison of polyphenol content and antioxidant capacity of colored potato tubers, pomegranate and blueberries, J Food Process Technol, 5(8):1-7.

Farvin K.H.S., Grejsen H.D. and Jacobsen C., 2012, Potato peel extract as a natural antioxidant in chilled storage of minced horse mackerel (Trachurus trachurus): Effect on lipid and protein oxidation, Food Chemistry, 131(3):843–851. https://doi.org/10.1016/j.foodchem.2011.09.056.

Freedman M.R. and Keast D.R., 2012, Potatoes, including French fries, contribute key nutrients to diets of U.S. adults: NHANES 2003-2006, Journal of Nutritional Therapeutics, 1(1):1–11. https://doi.org/10.6000/1929-5634.2012.01.01.1.

Furrer A.N., Chegeni M. and Ferruzzi M.G., 2018, Impact of potato processing on nutrients, phytochemicals, and human health, Critical Reviews in Food Science and Nutrition, 58(1):146–168. https://doi.org/10.1080/10408398.2016.1139542.

Gonceariuc M., 2002, Realizări în ameliorarea speciei *Salvia sclarea* L., Buletinul ASM, Ştiinţe biologice, chimice şi agricole, 3(288), Chişinău, pp. 97-103.

Hamouz K., Lachman J., Čepl J., Dvořák P., Pivec V. and Prášilová M., 2008, Site conditions and genotype influence polyphenol content in potatoes, Hort Sci (Prague), 34:132–137. https://doi.org/10.17221/1894-HORTSCI.

Hellmann H., Goyer A. and Navarre D.A., 2021, Antioxidants in Potatoes: A Functional View on One of the Major Food Crops Worldwide, Molecules, 26(9):2446. https://doi.org/10.3390/molecules26092446.

Ignat I., Volf I. and Popa V.I., 2011. A critical review of methods for characterisation of polyphenolic compounds in fruits and vegetables, Food Chemistry, 126(4):1821–1835. https://doi.org/10.1016/j.foodchem.2010.12.026.

Jasicka-Misiak I., Poliwoda A., Petecka M., Buslovych O., Shlyapnikov V.A. and Wieczorek P.P., 2018, Antioxidant phenolic compounds in *Salvia officinalis* L. and *Salvia sclarea* L., Ecological Chemistry and Engineering, 25(1):133-142.

Joshipura K.J., Hu F.B., Manson J.E., Stampfer M.J., Rimm E.B., Speizer F.E., Colditz G., Ascherio A., Rosner B., Spiegelman D. and Willett W.C., 2001, The Effect of Fruit and Vegetable Intake on Risk for Coronary Heart Disease, Ann Intern Med, 134(12):1106–1114. https://doi.org/10.7326/0003-4819-134-12-200106190-00010.

Konda A.R., Nazarenus T.J., Nguyen H., Yang J., Gelli M., Swenson S., Shipp J.M., Schmidt M.A., Cahoon R.E., Ciftci O.N., Zhang C., Clemente T.E. and Cahoon E.B., 2020, Metabolic engineering of soybean seeds for enhanced vitamin E tocochromanol content and effects on oil antioxidant properties in polyunsaturated fatty acid-rich germplasm, Metabolic Engineering, 57:63–73. https://doi.org/10.1016/j.ymben.2019.10.005.

Kowalczewski P.Ł., Olejnik A., Białas W., Rybicka I., Zielińska-Dawidziak M., Siger A., Kubiak P. and Lewandowicz G., 2019, The Nutritional Value and Biological Activity of Concentrated Protein Fraction of Potato Juice, Nutrients, 11(7):1523. https://doi.org/10.3390/nu11071523.

Lemos M.A., Aliyu M.M. and Hungerford G., 2015, Influence of cooking on the levels of bioactive compounds in Purple Majesty potato observed via chemical and spectroscopic means, Food Chemistry, 173:462–467. https://doi.org/10.1016/j.foodchem.2014.10.064.

Ley W., 1968, "The Devil's Apples". For Your Information, Galaxy Science Fiction, pp. 118–125.

Lin S. and Shen Y., 2021, Dietary carotenoids intake and depressive symptoms in US adults, NHANES 2015–2016, Journal of Affective Disorders, 282:41–45. https://doi.org/10.1016/j.jad.2020.12.098.

Liu Y., Tikunov Y., Schouten R.E., Marcelis L.F.M., Visser R.G.F. and Bovy A., 2018, Anthocyanin Biosynthesis and Degradation Mechanisms in

Solanaceous Vegetables: A Review, Front Chem, 6:52. https://doi.org/10.3389/fchem.2018.00052.

Lombardo S., Pandino G. and Mauromicale G., 2014, The mineral profile in organically and conventionally grown "early" crop potato tubers, Scientia Horticulturae, 167:169–173. https://doi.org/10.1016/j.scienta.2014.01.006.

Mäder J., Rawel H. and Kroh L.W., 2009, Composition of Phenolic Compounds and Glycoalkaloids α-Solanine and α-Chaconine during Commercial Potato Processing, J Agric Food Chem, 57(14):6292–6297. https://doi.org/10.1021/jf901066k.

McGill C.R., Kurilich A.C. and Davignon J., 2013, The role of potatoes and potato components in cardiometabolic health: A review, Annals of Medicine, 45(7):467–473. https://doi.org/10.3109/07853890.2013.813633.

Mishra T., Raigond P., Thakur N., Dutt S. and Singh B., 2020, Recent Updates on Healthy Phytoconstituents in Potato: a Nutritional Depository, Potato Res, 63(3):323–343. https://doi.org/10.1007/s11540-019-09442-z.

Monsen E.R., 2000, Dietary Reference intakes for the antioxidant nutrients: Vitamin C, vitamin E, selenium, and carotenoids, J Am Dietetic Assoc, 100(6):1008–1009. doi: 10.1016/S0002-8223(00)00189-9.

Morar G., 1999, Cultura cartofului, Editura Risoprint, Cluj- Napoca.

Morita T., Oh-hashi A., Takei K., Ikai M., Kasaoka S. and Kiriyama S., 1997, Cholesterol-Lowering Effects of Soybean, Potato and Rice Proteins Depend On Their Low Methionine Contents In Rats Fed a Cholesterol-Free Purified Diet, The Journal of Nutrition, 127(3):470–477. https://doi.org/10.1093/jn/127.3.470.

Muntean L.S., Tămaş M., Muntean S., Muntean L., Duda M.M., Vârban D.I. and Florian S., 2007, Tratat de plante medicinale cultivate şi spontane, Ed. Risoprint Cluj-Napoca, 928 p, ISBN 978-973-751-463-9.

Nassar A.M.K., Sabally K., Kubow S., Leclerc Y.N. and Donnelly D.J., 2012, Some Canadian-Grown Potato Cultivars Contribute to a Substantial Content of Essential Dietary Minerals, J Agric Food Chem, 60(18):4688–4696. https://doi.org/10.1021/jf204940t.

Navarre D.A., Brown C.R. and Sathuvalli V.R., 2019, Potato Vitamins, Minerals and Phytonutrients from a Plant Biology Perspective, Am J Potato Res, 96(2):111–126. https://doi.org/10.1007/s12230-018-09703-6.

Noreen S., Sultan M., Akhter M.S., Shah K.H., Ummara U., Manzoor H., Ulfat M., Alyemeni M.N. and Ahmad P., 2021, Foliar fertigation of ascorbic acid and zinc improves growth, antioxidant enzyme activity and harvest index in barley (*Hordeum vulgare* L.) grown under salt stress, Plant Physiology and Biochemistry, 158:244–254. https://doi.org/10.1016/j.plaphy.2020.11.007

Oprea A., 1997, Căi dde sporire a eficienței economice a culturii cartofului în condițiile economice de piață din România, Teză de doctorat, USAMV București.

Parr A.J. and Bolwell G.P., 2000, Phenols in the plant and in man. The potential for possible nutritional enhancement of the diet by modifying the phenols content or profile, J Sci Food Agric, 80(7):985–1012. https://doi.org/10.1002/(SICI)1097-0010(20000515)80:7<985::AID-JSFA572>3.0.CO;2-7.

Pellaud S., Bory A., Chabert V., Romanens J., Chaisse-Leal L., Doan A.V., Frey L., Gust A., Fromm K.M. and Mène-Saffrané L., 2018, WRINKLED1 and ACYL-COA:DIACYLGLYCEROL ACYLTRANSFERASE1 regulate tocochromanol metabolism in Arabidopsis, New Phytol, 217(1):245–260. https://doi.org/10.1111/nph.14856.

Plămădeală B., 1996, Ghid practic de protecție a cartofului, Ed. Ceres, București.

Rasheed H., Ahmad D. and Bao J., 2022, Genetic Diversity and Health Properties of Polyphenols in Potato, Antioxidants, 11(4):603. https://doi.org/10.3390/antiox11040603.

Reddy B.J., Mandal R., Chakroborty M., Hijam L. and Dutta P., 2018, A Review on Potato (*Solanum Tuberosum* L.) and its Genetic Diversity, International Journal of Genetics, 10:360. https://doi.org/10.9735/0975-2862.10.2.360-364.

Rembiałkowska E., 2007, Quality of plant products from organic agriculture, J Sci Food Agric, 87(15):2757–2762. https://doi.org/10.1002/jsfa.3000.

Rexen B., 1976, Studies of protein of potatoes, Potato Res, 19(2):189–202. https://doi.org/10.1007/BF02360425.

Robert L., Narcy A., Rayssiguier Y., Mazur A. and Rémésy C., 2008, Lipid Metabolism and Antioxidant Status in Sucrose vs. Potato-Fed Rats, Journal of the American College of Nutrition, 27(1):109–116. https://doi.org/10.1080/07315724.2008.10719682.

Rodríguez G., Squeo G., Estivi L., Quezada Berru S., Buleje D., Caponio F., Brandolini A. and Hidalgo A., 2021, Changes in stability, tocopherols, fatty acids and antioxidant capacity of sacha inchi (Plukenetia volubilis) oil during French fries deep-frying, Food Chemistry, 340:127942. https://doi.org/10.1016/j.foodchem.2020.127942.

Rytel E., Tajner-Czopek A., Kita A., Aniołowska M., Kucharska A.Z., Sokół-Łętowska A. and Hamouz K., 2014, Content of polyphenols in coloured and yellow fleshed potatoes during dices processing, Food Chemistry, 161:224–229. https://doi.org/10.1016/j.foodchem.2014.04.002.

Sampaio S.L., Petropoulos S.A., Alexopoulos A., Heleno S.A., Santos-Buelga C., Barros L. and Ferreira I.C.F.R., 2020, Potato peels as sources of functional compounds for the food industry: A review, Trends in Food Science and Technology, 103:118–129. https://doi.org/10.1016/j.tifs.2020.07.015.

Sasazuki S., Sasaki S., Tsubono Y., Okubo S., Hayashi M. and Tsugane S., 2006, Effect of vitamin C on common cold: randomized controlled trial, Eur J Clin Nutr, 60(1):9–17. https://doi.org/10.1038/sj.ejcn.1602261.

Sepelev I. and Galoburda R., 2015, Industrial potato peel waste application in food production: a review, Res Rural Dev 1:130-136.

Silva C.S., Moutinho C., Ferreira da Vinha A. and Matos C., 2019, Trace minerals in human health: iron, zinc, copper, manganese and fluorine, International Journal of Science and Research Methodology, 13(3):57–80.

Singh P.P. and Saldaña M.D.A., 2011, Subcritical water extraction of phenolic compounds from potato peel, Food Research International, 44(8):2452–2458. https://doi.org/10.1016/j.foodres.2011.02.006.

Smitherman L.C., Janisse J. and Mathur A., 2005, The Use of Folk Remedies Among Children in an Urban Black Community: Remedies for Fever, Colic, and Teething, Pediatrics, 115(3):e297–e304. https://doi.org/10.1542/peds.2004-1443.

Spooner D.M., 2013, *Solanum tuberosum* (Potatoes), in: Brenner's Encyclopedia of Genetics, Elsevier, pp. 481–483. https://doi.org/10.1016/B978-0-12-374984-0.01442-X.

Sun X., Jin X., Fu N. and Chen X., 2020, Effects of different pretreatment methods on the drying characteristics and quality of potatoes, Food Sci Nutr, 8(11):5767–5775. https://doi.org/10.1002/fsn3.1579.

Tan J.S.L., Wang J.J., Flood V., Rochtchina E., Smith W. and Mitchell P., 2008, Dietary Antioxidants and the Long-term Incidence of Age-Related Macular Degeneration, Ophthalmology, 115(2):334–341. https://doi.org/10.1016/j.ophtha.2007.03.083.

Valiñas M.A., Lanteri M.L., Ten Have A. and Andreu A.B., 2017, Chlorogenic acid, anthocyanin and flavan-3-ol biosynthesis in flesh and skin of Andean potato tubers (*Solanum tuberosum* subsp. *andigena*), Food Chemistry, 229:837–846. https://doi.org/10.1016/j.foodchem.2017.02.150.

Vlachojannis J.E., Cameron M. and Chrubasik S., 2010a, Medicinal use of potato-derived products: a systematic review, Phytother Res, 24(2):159–162. https://doi.org/10.1002/ptr.2829.

Vlachojannis J.E., Cameron M. and Chrubasik S., 2010b, Medicinal use of potato-derived products: a systematic review, Phytother Res, 24(2):159–162. https://doi.org/10.1002/ptr.2829.

Yang Y., Achaerandio I. and Pujolà M., 2016, Classification of potato cultivars to establish their processing aptitude: Classification of potato cultivars, J Sci Food Agric, 96(2):413–421. https://doi.org/10.1002/jsfa.7104.

***Catalogul oficial al soiurilor de plante de cultură din România pentru anul 2012.

*** www.faostat.fao.org - accessed on 26 September 2022.