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THE NUTRITIONAL VALUE AND HEALTH BENEFITS OF SWEET CORN KERNELS (*ZEA MAYS* SSP. *SACCHARATA*)

WARTOŚCI ODŻYWCZE I WŁAŚCIWOŚCI PROZDROWOTNE ZIARNA KUKURYDZY CUKROWEJ (*ZEA MAYS* SSP. *SACCHARATA*)

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Authors' contribution
Wkład autorów:
A. Study design/planning
zaplanowanie badań
B. Data collection/entry
zebranie danych
C. Data analysis/statistics
dane – analiza i statystyki
D. Data interpretation
interpretacja danych
E. Preparation of manuscript
przygotowanie artykułu
F. Literature analysis/search
wyszukiwanie i analiza literatury
G. Funds collection
zebranie funduszy

Summary

The aim of this paper was to review scientific studies concerning the nutritional value and healthy properties of sweet corn kernels. Sweet corn (*Zea mays* ssp. *saccharata*) is a popular vegetable in America and many European countries. It is also increasingly recognized in Poland. The practical benefits of sugar corn result, among others, from the nutritional value of caryopses and their taste. The review of the literature of the research subject presented in this paper allows us to state that sugar corn caryopses are a source of carbohydrates (simple sugars, starch), protein, vitamins, mineral ingredients, phenolic acids, carotenoids and dietary fiber. The results of chemical analyses prove that sugar corn kernels do not contain gluten; therefore, this plant plays a particularly important role in the nutrition of people with coeliac disease, and corn flour is a valuable product in the food industry. An increasing number of research evidence shows that the regular consumption of wholemeal corn reduces the risk of developing many chronic diseases, such as cardiovascular diseases, eye diseases, obesity, type 2 diabetes, and digestive diseases. The analysis of the literature of the research subject allows us to conclude that sugar corn should be a permanent element of everyday diet, particularly because it can be consumed both in a fresh and processed form all year round.

Keywords: sweet corn, chemical constitution, nutritional value, health benefits, nutrition

Streszczenie

Celem pracy był przegląd opracowań naukowych na temat wartości odżywczej oraz właściwości prozdrowotnych ziarna kukurydzy cukrowej. Kukurydza cukrowa (*Zea mays* ssp. *saccharata*) jest popularnym warzywem w Ameryce, a także w wielu krajach europejskich. Również w Polsce warzywo to cieszy się coraz większym uznaniem. Zalety użytkowe kukurydzy cukrowej wynikają między innymi z wartości odżywczej ziarniaków oraz ich walorów smakowych. Przegląd literatury przedmiotu badań przedstawiony w niniejszej pracy pozwala stwierdzić, że ziarniaki kukurydzy cukrowej są źródłem węglowodanów (cukry proste, skrobia), białka, witamin, składników mineralnych, kwasów fenolowych, karotenoidów oraz błonnika pokarmowego. Z analiz chemicznych wynika, że ziarno kukurydzy cukrowej nie zawiera glutenu, dlatego roślina ta ma szczególne znaczenie w żywieniu osób chorych na celiakię, a mąka kukurydziana jest cennym surowcem w przemyśle spożywczym. Coraz więcej dowodów naukowych pokazuje, że regularne spożywanie kukurydzy pełnoziarnistej zmniejsza ryzyko rozwoju wielu chorób przewlekłych, takich, jak choroby sercowo-naczyniowe, choroby oczu, otyłość, cukrzyca typu II oraz choroby układu trawiennego. Na podstawie analizy literatury stwierdzono, że kukurydza cukrowa powinna być stałym elementem codziennej diety. Tym bardziej, że może być ona spożywana przez cały rok zarówno w postaci świeżej, jak również przetworzonej.

Słowa kluczowe: kukurydza cukrowa, skład chemiczny, wartości odżywcze, właściwości prozdrowotne, odżywianie

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Introduction

Corn *Zea mays* L. (the name of the plant comes from two Greek words: *zea* – sustaining life, *mays* – life-giver) is a source of nutrients and phytochemicals; it is a plant of versatile use. It is also called the queen of cereals and Indian gold. Corn is one of the most important and the oldest plants cultivated around the world [1,2].

It was already known in prehistoric times. This plant is associated with civilizations of the ancient Maya and Aztecs, for whom it was not only a basic dietary item but also an object of beliefs and religious cult. On the basis of archaeological works, we can conclude that this plant has been cultivated for over 4,500 years. After the discovery of America by Christopher Columbus, the cultivation of corn started in Asia, Australia, Africa and Europe. In Poland, the first historical sources about the cultivation of this plant date back to the late 18th century [3,4].

Zea mays L. belongs to the botanical family of *Graminaceae* grasses; it is an annual and thermophilic plant. Corn is characterized by a large abundance of forms with very different botanical and practical characteristics. There are eight subspecies of corn, which vary mainly in the structure of caryopses. Those that are economically the most important include: flint corn (*Zea mays* ssp. *indurata*); dent corn (*Zea mays* ssp. *indentata*); popcorn (*Zea mays* ssp. *everta*); and **sweet corn (*Zea mays* ssp. *saccharata*)** that is cultivated as a vegetable plant. It is a hybrid grown specially in order to increase the sugar content; its caryopses contain an endosperm rich in amylodextrins, which are responsible for their sweet taste. It must be stressed that currently cultivated varieties of corn, including sweet corn, are hybrids derived most frequently from flint corn and dent corn [3].

Sweet corn is a fully domesticated plant (it does not occur in the wild state). The subspecies bearing the name *Zea mays* ssp. *saccharata* was separated in 1820. The first breeder and producer of seeds of hybrid varieties was Noyes Darling from the State of Connecticut in the USA. In subsequent years, as a result of progress in breeding work and the nutritional value and taste of its kernels, sweet corn became an important plant widely cultivated in many countries around the world, with the size of this production constantly increasing. In the USA, sweet corn is a "national vegetable". Its annual consumption exceeds 11 kg per capita there. In Poland, it is around 0.5 kg per person [5,6].

In Poland, however, the cultivation of this plant is increasingly popular mainly due to its taste and the introduction of new varieties adapted to domestic climate conditions [7]. These varieties differ in the length of the vegetation period (early, medium early and late varieties), the height and habit of plants, the color and shape of caryopses, yield and sugar content in a kernel. We distinguish normal sugary varieties (SU type) containing 4-6% of sugars in the fresh kernel mass, sugary enhancement varieties (SE type) (6-8%), as well as super-sweet shrunken varieties (SH type) (8-12%). Varieties of sweet corn differ also in suitability for various directions of use (e.g., kernels are intended for direct consumption and for processing) [5,8-10].

Sweet corn kernels contain many important nutritional and healthy ingredients. The popularity of corn grows also due to the lack of gluten in caryopses and due to the content of zein – a protein present in the endosperm of caryopses that is used, among others, in pharmacy and in the production of nutraceuticals [1,11-13].

Research shows that the regular consumption of corn reduces the risk of developing many civilizational diseases, such as type 2 diabetes, obesity, cardiovascular diseases, and digestive diseases [11].

The benefits of sweet corn kernels resulting from their nutritional value and healthy properties are sufficient arguments for making this plant an important dietary component.

Aim of the work

The aim of the paper was to present synthetically major issues concerning the nutritional value and healthy properties of sweet corn kernels on the basis of an analysis of the literature of the research subject.

Results of the literature review on the research subject

Chemical constitution and major nutritional value of sweet corn kernels

The chemical constitution and nutritional value of sweet corn kernels depends on many factors, including the genotype, weather conditions during the growth of plants, agrotechnical measures, the phase of ripeness of caryopses, processing and the type of food product [14-17].

The chemical constitution of whole potatoes contain valuable profiles of nutrients and phytochemicals in comparison to other full cereal grains; 100 g of sweet corn kernels provide around 111 kcal [11,15,18]. Varieties of sweet corn, particularly with color caryopses, have a higher anti-oxidation capacity in comparison to wheat or oat grains [19].

The nutritional value of caryopses results from their content of water (72.7%) and solids (27.3%). Solids contain carbohydrates (81%), proteins (13%), fats (3.5%) and other ingredients (2.5%) [20].

Caryopses of very sweet varieties contain many water-soluble sugars (glucose, fructose, saccharose) (6-12%). Also thanks to the starch (polysaccharide) content, kernels are good products for the production of flour and cornflakes. It must be stressed that the sugar content decreases and the starch content increases along with the degree of ripeness of caryopses. On the average, 100 g of fresh caryopses of sweet corn contains around: 23.4 g of carbohydrates (monosaccharides, starch, cellulose), 3.7 g of protein, 1.5 g of fat and 3.3 g of dietary fiber. Other valuable nutrients of sweet corn are macro- and microelements and vitamins (Table 1).

Table 1. The content of major nutrients in 100 g of fresh sweet corn caryopses [21,22]

Macroelements		**Microelements**	
Calcium	2 mg	Zinc	0.46 mg
Magnesium	37 mg	Copper	0.054 mg
Phosphorus	89 mg	Iron	0.52 mg
Potassium	270 mg	Manganese	0.163 mg
Sodium	15 mg	Selenium	0.6 µg
Vitamins			
Vitamin A		9 µg	
Vitamin B1		0.155 mg	
Vitamin B2		0.055 mg	
Vitamin B3		1.77 mg	
Vitamin B4		23 mg	
Vitamin B5		0.717 mg	
Vitamin B6		0.093 mg	
Vitamin B9 (folacin, folic		42 µg	
Vitamin C		6.8 mg	
Vitamin E		0.07 mg	
Vitamin K		0.3 µg	

Sweet corn caryopses contain potassium, phosphorus, magnesium and small quantities of sodium and calcium. Sweet corn is a source of vitamins, including vitamin A (9 μg), vitamins B, vitamin K (phylloquinone) (0.3 μg) and folic acid (vitamin B9) (42 μg) (Table 1) [21,22]. Important ingredients of sweet corn kernels are microelements, such as selenium (0.6 μg), which – along with vitamin E and beta carotene – reduces the metabolic activation of carcinogens and contributes to the detoxification of substances harmful to our body. Caryopses contain also microelements such as zinc (0.46 mg), copper (0.054 mg), iron (0.52 mg), and manganese (0.11 mg) (Table 1). Another ingredient of sweet corn kernels is oil (from 3.1 to 5.7%) – a rich source of unsaturated fatty acids and bioactive substances, such as phytosterols and carotenoids (zeaxanthin and lutein, approx. 644 μg/100 g) [22], which are responsible for the yellow color of caryopses. It is also important to note the presence of dietary fiber (including resistant starch), which plays a crucial role in ensuring the proper functioning of the digestive system [15,18,23-26].

Sweet corn is a vegetable for universal use in human nutrition. It contains no gluten and, therefore, plays a special role in the diet of people with coeliac disease (which is characterized by a permanent intolerance of gluten). The allergy to gluten makes it necessary to eliminate cereal products from the diet; for this reason, sweet corn kernels are often used for the production of gluten-free food, particularly for children.

Sweet corn is a food product with an average or high glycemic index (GI) (the average GI of sweet corn boiled in water is 59); some other foods, like cornflakes or pasta, have a much higher GI, which reduces the frequent consumption of these products by people with coeliac disease [25,27,28].

According to Capili et al. [29], the consumption of corn kernels is not recommended for people suffering from irritable bowel syndrome, either.

Ripeness, time of harvest and storage of sweet corn caryopses depending on the direction of use

Because the chemical constitution of sweet corn kernels is not stable and changes very quickly, the phase of ripeness, the time of harvest and the temperature of storage of sweet corn kernels are very important. Caryopses intended *for direct consumption* reach eating ripeness in the initial stage of milk-wax ripeness. At that time, they contain 70-80% of water. When harvested in this phase, they taste best, are juicy and soft and have a high sugar content (6-12%). When the harvest is delayed, caryopses are unfit for direct consumption, and their value largely deteriorates. They become hard and mealy, contain less sucrose, which is responsible for their sweet taste, and the content of starch increases. Their nutritional value is lower, and their sensory characteristics are not accepted by consumers [15,23].

After the harvest, sweet corn kernels must be immediately cooled down to a temperature of around 0°C as quickly as possible. Time is very important here because of many sensory processes occurring in caryopses at higher temperatures, such as the conversion of monosaccharides into starch, which leads to the deterioration of the sensory quality of kernels intended for direct consumption [14,30].

The period of storage of sweet corn intended for direct consumption is very limited; sweet corn can be stored for maximum 6-8 days at the temperature of 0°C, for 3-4 days at the temperature of 5°C and for 2 days at the temperature of 10°C. It must be stressed that kernels stored at the temperature of 24°C lose around 30% of sugar after 24 hours. For the extension of the nutritional value of caryopses intended for direct consumption, they are subjected to the blanching procedure and then frozen at the temperature of –40°C. Then the frozen corn is stored at a temperature of approx. –20°C [15,23,31].

Ears of sweet corn *intended for cooking* should be harvested at the full or final phase of milk ripeness. When subsequently frozen, they can be stored even for a few months. This measure is used in order to stop the activity of enzymes responsible for the conversion of monosaccharides into starch and a change in the color of kernels.

Kernels *to be used as a product in the processing industry* should be harvested at the phase of late-milk ripeness. At this phase, it contains most nutrients. The dry mass content in kernels amounts to 24-28% at that moment. Sweet corn intended for direct consumption and for the processing industry must be harvested in the morning or in the evening (when temperatures are the lowest during the day) [23].

The use of corn caryopses for consumption purposes

For consumption purposes, sweet corn is used most frequently for direct consumption, for frozen and canned foods in the fruit and vegetable processing industry (e.g., corn kernels in brine, mixtures with other vegetables) and as a raw product in industry (flours, groats, bran, pasta) [6,23].

Depending on the region, culinary tradition and eating habits, corn can be consumed in a fresh form, and kernels can also be processed and eaten as snacks, tortilla, groats, cornflakes (produced from squeezed and cooked kernels), corn chips or corn wafers. A popular dish in Italy is polenta – corn flour cooked into a thick pulp and seasoned with garlic and herbs. Mămăligă – a similar Romanian dish – is corn flour cooked into a pulp, layered with goat cheese and baked; before serving, it is poured with sour cream. Corn gruels and corn flour pancakes are basic foods in African countries [6].

Ears of corn can also be cooked, grilled, blanched, preserved or frozen. Sweet corn kernels are used for making corn flour (obtained as a result of grinding corn kernels), corn starch (used as a dish thickener and an addition to pastries), corn syrup (glucose-fructose syrup obtained from corn starch, not recommend in excess quantities in the diet) and corn oil (present mainly in the germ of a caryopsis) [1,6,14,16,24]. It is worth mentioning that corn malt is used for the production of fermented beverages [32]. Sprouts of corn caryopses rich in nutrients are a valuable product in our diet [33].

Nutritional value of selected products obtained from sweet corn kernels

According to Prasanthi et al. [34], sweet corn kernels consumed in full, for example, in a fresh form or as popcorn are of higher nutritional value than corn flour, which does not contain germs of caryopses rich in nutrients and corn bran. In addition, corn flour contains small amounts of amino acids – lysine and tryptophan, which participate in the synthesis of vitamin PP (niacin). Thus, in countries where corn flour is the basis of the diet, soy flour containing many of those amino acids is added to this flour [6,34].

It is also worth stressing that corn bran – mainly the external, most valuable layer of the caryopsis, or a fruit-seed cover with a part of the endosperm and the germ – is a valuable product in our diet. Corn bran is a by-product of grinding corn kernels; it is of high nutritional value, abounds in minerals, vitamins, dietary fiber (resistant starch), etc., and does not contain anti-nutritional substances [34]. The presence of dietary fiber ensures the feeling of satiety. Adding corn bran to our diet can have a favorable impact on the functioning of the digestive tract, a decrease in weight gain and obesity. Corn bran can play a valuable part in the production of snacks [35].

Corn oil belongs to a group of oils of higher nutritional value due to the high content of unsaturated acids, particularly linoleic acid. Among refined vegetable oils, it contains one of the highest, naturally occurring level of phytosterols, which play a significant part in preventive measures against diseases of the cardiovascular system, and carotenoids, which are natural antioxidants [24].

Healthy properties of sweet corn kernels

Research proves that the regular consumption of wholemeal products reduces the risk of developing chronic diseases, including diseases of the cardiovascular system, type 2 diabetes, overweight and obesity, and digestive disorders. The entire sweet corn kernel provides a wide range of vitamins B, vitamin E, A, C and K,

minerals, microelements (Table 1), carbohydrates, dietary fiber (including resistant starch), protein and fats [1,11,36].

Vitamins B have many important functions in the human body; for example, they are responsible for the proper functioning of the nervous system. They are not produced and stored in the body and, therefore, must be delivered with food [37]. The use of vitamins B is necessary for the absorption of copper and calcium and the production of red blood cells and enzymes. Sweet corn is also a source of iron, which is essential for the formation of red blood cells [38].

Sweet corn caryopses contain beta carotene, which is the precursor of vitamin A (retinol). Beta carotene is transformed into vitamin A and ensures the proper maintenance of our skin and vision. Vitamin A also supports mucous membranes and the immune system [25]. Caryopses contain also vitamin E, which is called a "vitamin of youth" [10]. It is a fat-soluble antioxidant obtained only from the diet. It has been found that antioxidant properties of vitamin E play an important role in fighting many civilizational diseases, including atherosclerosis, ageing, cancers, cataract and arthritis [39]. Vitamin C prevents scurvy and contributes to the primary prevention of common and complex civilizational diseases, such as ischemic heart disease, stroke or cancers [40]. Research indicates that vitamin K plays a significant part in alleviating the ageing process and preventing age-related diseases. This results mainly from its antioxidant and anti-inflammatory properties. It can also improve the effectiveness of some treatment methods among adults (over the age of 50 years) [41].

The presence of vitamins A, C and K and beta carotene and selenium helps to improve the functioning of the thyroid gland and the immune system. Selenium also plays a very important role in anti-cancer prevention [9].

Caryopses of sweet corn are a source of phytochemicals, including carotenoids, phenolic compounds, phytosterols and dietary fiber, including resistant starch [11,42]. Phytochemicals (Greek: *fitón* – plant) are bioactive non-nutritive chemical compounds that are naturally present in plants (vegetables, fruits, wholemeal products). Because of their strong antioxidant effect, they have a favorable impact on the decrease of the risk of many chronic diseases, including some cancers, cardiovascular diseases, type 2 diabetes and obesity [27,43].

Carotenoid colorants responsible for the yellow color of corn caryopses are lutein and zeaxanthin (100 g of caryopses contain approx. 644 μg of lutein and zeaxanthin) [22]. They are the main pigments located in the macula of the human retina, which protect the macula against photo damage and improve visual acuity. Their supplementation in the diet helps to reduce the risk of age-related macular degeneration and cataract [44].

Corn oil is a rich source of unsaturated fatty acids and bioactive substances, such as phytosterols and carotenoids. Phytosterols are regarded as compounds reducing the level of cholesterol and, therefore, having a healthy effect [24]. The consumption of corn oil in the long term may reduce the blood concentration of cholesterol and prevent atherosclerosis [45]. According to Shah et al., [1] one spoonful of corn oil meets the daily demand for essential unsaturated fatty acids in a healthy child or an adult [1].

Dietary fiber present in corn caryopses accelerates intestinal motility, making it easier for gastric content to pass through the digestive tract, and reduces the absorption of cholesterol and the blood concentration of glucose. It is particularly important to note the presence of resistant starch, which is an insoluble ingredient of dietary fiber. Resistant starch consists of indigestible fermenting dietary fibers that are resistant to digestion in the small intestine but are fermented in the large intestine. Introducing resistant starch into the diet brings a number of health benefits, including smaller storage of the adipose tissue [1,46], thereby reducing the risk of atherosclerosis, diabetes and obesity [47].

Healthy properties of sweet corn kernels are still not fully explored; therefore, further research on this valuable plant is justified.

Conclusions

Sweet corn kernels are an essential part of everyday diet for many people around the world and can be eaten in a fresh, frozen or processed form. It is a product with valuable taste, nutritional and healthy properties. Research proves that sweet corn kernels are also a rich source of non-nutritive substances – phytochemicals, including carotenoids, which have a very strong antioxidation effect. Foods rich in antioxidants play a significant part in preventive health care. Research proves the preventive effect of bioactive ingredients present in sweet corn caryopses with regard to many civilizational diseases of the 21st century. This means that knowledge in this respect must be constantly updated. The modification of everyday diet through an increased consumption of sweet corn kernels can help to reduce the risk of many chronic diseases.

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References:

1. Shah TR, Prasad K, Kumar P. Maize – a potential source of human nutrition and health: a review. Cogent Food & Agriculture. 2016; 2: 166995. https://doi.org/10.1080/23311932.2016.1166995
2. Kumar D, Jhariya NA. Nutritional, medicinal and economical importance of corn: a mini review. Research Journal of Pharmaceutical Sciences. 2013; 2(7): 7-8.
3. Jasińska Z, Kotecki A., editors. [Detailed plant cultivation]. Wrocław: Wyd. Akademii Rolniczej we Wrocławiu; 2003 (in Polish).
4. Smith CW, Betrán J, Runge EC., editors. Corn: origin, history, technology, and production. Hoboken: John Wiley & Sons; 2004.
5. Niedziółka I, Szymanek M, Rybczyński R. [Sweet corn prpduction technology]. Acta Agrophysica. Rozprawy i Monografie. Instytut Agrofizyki im. Bohdana Dobrzańskiego PAN w Lublinie. 2004 (in Polish).
6. Waligóra H. [Growing and using sweetcorn for food. Maize]. Pismo Polskiego Związku Producentów Kukurydzy. Poznań. 2021; 2(59): 17-25 (in Polish).
7. Machul M. [Progress in the breeding of maize hybrids grown in Poland between 1976 and 2000]. Pam. Puław. 2002; 130: 479-486 (in Polish).
8. Szymanek M, Niedziółka I, Dobrzański B. [Physical properties of sweetcorn grain in terms of its mechanical severing]. Acta Agroph. Rozprawy i Monografie. Lublin; 2004 (in Polish).
9. Waligóra H, Weber A, Skrzypczak W, Idziak R. [Economic value of new hybrids of the sweet maize (Zea mays ssp. Saccharata Koern.)]. Biuletyn IHAR. 2011; 260/261: 285-292 (in Polish). https://doi.org/10.37317/biul-2011-0042
10. Warzecha R. [Sweetcorn production for the processing industry and fresh market]. Kukurydza. 2006; 2(28): 29-31 (in Polish).
11. Sheng S, Li T, Liu R. Corn phytochemicals and their health benefits. Food Science and Human Wellness. 2018; 7(3): 185-195. https://doi.org/10.1016/j.fshw.2018.09.003
12. Tighe P, Duthie G, Vaughan N, Brittenden J, Simpson WG, Duthie S, et al. Effect of increased consumption of whole-grain foods on blood pressure and other cardiovascular risk markers in healthy middle-aged persons: a randomized controlled trial. Am. J. Clin. Nutr. 2010; 92(4): 733-740. https://doi:10.3945/ajcn.2010.29417

13. Shah TR, Prasad K, Kumar P. Studies on physicochemical and functional characteristics of asparagus bean flour and maize flour. In: Mishra CC., editor. Conceptual frame work & innovations in agroecology and food sciences. 1st edition. New Delhi: Krishi Sanskriti Publications; 2015. p. 103-105.
14. Revilla P, Anibas CM, Tracy WF. Sweet corn research around the world 2015-2020. Agronomy. 2021; 11(3): 534. https://doi.org/10.3390/agronomy11030534
15. Szymanek M, Dobrzański B, Niedziółka I, Rybczyński R. [Sweetcorn, harvesting technology, physical properties and quality]. Lublin: Instytut Agrofizyki im. Bohdana Dobrzańskiego PAN w Lublinie; 2005 (in Polish).
16. Szymanek M, Dziwulska-Hunek A, Tanas W. Influence of blanching time on moisture, sugars, protein, and processing recovery of sweet corn kernels. Processes. 2020; 8(3): 340. https://doi.org/10.3390/pr8030340
17. Calvo-Brenes P, O'Hare T. Effect of freezing and cool storage on carotenoid content and quality of zeaxanthin-biofortified and standard yellow sweet-corn (*Zea mays* L.). J. Food Comp. Anal. 2020; 86: 103353. https://doi.org/10.1016/j.jfca.2019.103353
18. Pyryt A, Linda A. [Quality of tinned corn available for retail sale]. Zeszyty Naukowe Akademii Morskiej w Gdyni. 2017; 99: 124-130 (in Polish).
19. Escalante-Aburto A, Ramírez-Wong B, Torres-Chávez PI, Barrón-Hoyos J, de Dios Figueroa-Cárdenas J, López-Cervantes J. The nixtamalization process and its effect on anthocyanin content of pigmented maize, a review. Rev. Fitotec. Mex. 2013; 36(4): 429-437. https://doi.org/10.35196/rfm.2013.4.429
20. Hardenburg RE, Watada AE. The comercial storage of fruits, vegetables, and florist and nursery stocks. Handbook 66. Washington: U.S. Dept. Agric.; 1986.
21. Kunachowicz H, Nadolna I, Iwanow K, Przygoda B. [Nutritional value of selected foods and typical dishes]. Warszawa: Wyd. Lekarskie PZWL; 1999 (in Polish).
22. fdc.nal.usda.gov [Internet]. Washington: U.S. Department of Agriculture; 2019 Jan 4. Agricultural Research Service: Corn, sweet, yellow, raw [access 2023 Oct 2]. Available from: https://fdc.nal.usda.gov/fdc-app.html#/food-details/169998/nutrients
23. Waligóra H. [Production and utilization of sweet corn in Poland]. Zeszyty Problemowe Postępów Nauk Rolniczych. 1997; 450: 219-230 (in Polish).
24. Susik J. [Corn oil production methods determining its chemical properties]. Żywność. Nauka. Technologia. Jakość. 2021; 28(4): 47-56 (in Polish). https://doi.org/10.15193/zntj/2021/129/399
25. Swapna G, Jadesha G, Mahadevu P. Sweet corn – a future healthy human nutrition food. Int. J. Curr. Microbiol. App. Sci. 2020; 9(7): 3859-3865. https://doi.org/10.20546/ijcmas.2020.907.452
26. Rubatzky VE, Yamaguchi M. Sweet corn, *Zea mays* L. In: Rubatzky VE, Yamaguchi M., editors. World vegetables: principles, production, and nutrive values. Berlin: International Thomson Publ; 1997. p. 235-252. https://doi.org/10.1007/978-1-4615-6015-9_15
27. Siyuan S, Li T, Liu RH. Corn phytochemicals and their health benefits. Food Science and Human Wellness. 2018; 7(3): 185-195. https://doi.org/10.1016/j.fshw.2018.09.003
28. Capili B, Anastasi JK, Chang M. Addressing the role of food in irritable bowel syndrome symptom management. J. Nurse. Pract. 2016; 12(5): 324-329. https://doi.org/10.1016/j.nurpra.2015.12.007
29. Vahini J, Bhaskarachary K, Vishnu Vardhan Rao M. Effect of cooking on glycemic index of commonly consumed corn in Inda. International Journal of Food and Nutritional Sciences. 2017; 6(1): 25-30.
30. Xie Y, Liu S, Jia L, Gao E, Song H. Effect of different storage temperatures on respiration and marketable quality of sweet corn. Adv. Eng. Technol. 2017; 3: 219-224. https://doi.org/10.1201/9781315387222-31
31. Geeta HP, Palanimuthu V, Srinivas G. Study of some physico-chemical properties of sweet corn. International Journal of Agricultural Science and Research. 2017; 7(1): 277-286. https://doi.org/10.5958/2277-9396.2017.00017.4

32. Flores-Calderón AMD, Luna H, Escalona-Buendía HB, Verde-Calvo JR. Chemical characterization and antioxidant capacity in blue corn (*Zea mays* L.) malt beers. Journal of the Institute of Brewing. 2017; 123(4): 506-518. https://doi.org/10.1002/jib.444
33. Xiang N, Guo XB, Liu FY, Li Q, Hu JG, Brennan CS. Effect of light-and dark-germination on the phenolic biosynthesis, phytochemical profiles, and antioxidant activities in sweet corn (*Zea mays* L.) sprouts. Int. J. Mol. Sci. 2017; 18(6): 1246. https://doi.org/10.3390/ijms18061246
34. Prasanthi PS, Naveena N, Rao MV, Bhaskarachary K. Compositional variability of nutrients and phytochemicals in corn after processing. J. Food. Sci. Technol. 2017; 54(5): 1080-1090. https://doi.org/10.1007/s13197-017-2547-2
35. Figueiredo de Sousa M, Guimarães RM, de Oliveira Araújo M, Barcelos KR, Carneiro NS, Lima DS, et al. Characterization of corn (*Zea mays* L.) bran as a new food ingredient for snack bars. LWT. 2019; 101: 812-818. https://doi.org/10.1016/j.lwt.2018.11.088
36. Garutti M, Nevola G, Mazzeo R, Cucciniello L, Totaro F, Bertuzzi CA, et al. The impact of cereal grain composition on the health and disease outcomes. Front Nutr. Sec. Clinical Nutrition. 2022; 25(9): 888974. https://doi.org/10.3389/fnut.2022.888974
37. Kennedy DO. B vitamins and the brain: mechanisms, dose and efficacy – a review. Nutrients. 2016; 8(2): 68. https://doi.org/10.3390/nu8020068
38. Budak F, Aydemir SK. Grain yield and nutritional values of sweet corn (*Zea mays var. saccharata*) in produced with good agricultural implementation. Nutri. Food. Sci. Int. J. 2018; 7(2): 555710. https://doi.org/10.19080/NFSIJ.2018.07.555710
39. Rizvi S, Raza ST, Ahmed F, Ahmad A, Abbas S, Mahdi F. The role of vitamin E in human health and some diseases. Sultan Qaboos Univ Med J. 2014; 14(2): 157-65.
40. Granger M, Eck P. Dietary vitamin C in human health. Adv Food Nutr Res. 2018; 83: 281-310. https://doi:10.1016/bs.afnr.2017.11.006
41. Popa DS, Bigman G, Rusu ME. The role of vitamin K in humans: implication in aging and age-associated diseases. Antioxidants. 2021; 10(4): 566. https://doi.org/10.3390/antiox10040566
42. Lopez-Martinez LX, Oliart-Ros RM, Valerio-Alfaro G, Lee CH, Parkin KL, Garcia HS. Antioxidant activity, phenolic compounds and anthocyanins content of eighteen strains of Mexican maize. LWT – Food Science and Technology. 2009; 42(6): 1187-1192. https://doi:10.1016/J.LWT.2008.10.010
43. Liu RH. Potential synergy of phytochemicals in cancer prevention: mechanism of action. J. Nutr. 2004; 134(12): 3479-3485. https://doi.org/10.1093/jn/134.12.3479S
44. Abdel-Aal E-SM, Akhtar H, Zaheer K, Ali R. Dietary sources of lutein and zeaxanthin carotenoids and their role in eye health. Nutrients. 2013; 5(4): 1169-1185. https://doi.org/10.3390/nu5041169
45. Ostlund RE, Racette SB, Okeke A, Stenson WF. Phytosterols that are naturally present in commercial corn oil significantly reduce cholesterol absorption in humans. American Journal of Clinical Nutrition. 2002; 75(6): 1000-1004. https://doi.org/10.1093/ajcn/75.6.1000
46. Shen L, Keenan MJ, Martin RJ, Tulley RT, Raggio AM, McCutcheon KL, et al. Dietary resistant starch increases hypothalamic POMC expression in rats. Obesity. 2009; 17(1): 40-45. https://doi.org/10.1038/oby.2008.483
47. Higgins JA. Resistant starch: metabolic effects and potential health benefits. Journal of AOAC International. 2004; 87: 761-768. https://doi.org/10.1093/jaoac/87.3.761