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MEDICINAL PROPERTIES OF BUCKWHEAT PRODUCTS AND HONEY IN COMPLIANCE WITH FOOD SAFETY REGULATORY REQUIREMENTS

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ABSTRACT

Buckwheat (*Fagopyrum esculentum* Moench) is a gluten-free pseudo-cereal and honey plant. Buckwheat grain yields vary greatly and depend on the genotype, agro-ecological conditions of production and harvesting method. The grain yield of the 'Novosadska' variety varies 1.5-3 t $ha^{-1}$and the honey yield amounts and more than 300 kg ha^{-1}. Buckwheat grain contains: carbohydrates, proteins, fats, organic acids and rutin (quercetin-3-rutinosid), minerals (potassium, phosphorus, calcium, magnesium, sodium, iodine, zinc, bromine and iron), vitamins (D_2-ergokalciferol, D_3-holekalciferol, P-bioflavonoids, vitamins group B: B_1-Thiamine, B_2-Riboflavin, B_3-niacin, B_4-Choline, B_5-Pantothenic acid, B_6-Piridoxin, B_9-Folate; and vitamin E-Tocopherols. 'Novosadska' buckwheat contains the highest level of phenolic acids, proanthocyanidins, flavones and flavonols. Buckwheat honey is dark color, which it gets from polyphenols. Polyphenols is antioxidants, organic compounds which affect the quality of food, especially the color and taste. In accordance with the law on food safety, the interests of consumers must be ensured the highest level of protection. Phenolic antioxidants from honey are bioavailable and increase the antioxidant activity of plasma. Buckwheat honey has a beneficial effect on bronchitis and cough, hypertension, arteriosclerosis, of heart disease, liver and intestinal diseases and has antibacterial effects.

Key words: buckwheat, medicinal plants, 'Novosadska', honey, use in medicine.

INTRODUCTION

Common buckwheat (*Fagopyrum esculentum* Moench; 2n = 2x = 16) is pseudo-cereal but also a source of honey and a decorative plant. Buckwheat was cultivated in China a thousand years ago. Buckwheat belongs to the order *Polygonales*, family *Polygonaceae*, genus *Fagopyrum* which has 15 annual and perennial species. The following three species are interesting for cultivation: *Fagopyrum esculentum* Moench. - Common buckwheat, *Fagopyrum tataricum* (L.) Gaertn. - Tatar buckwheat and *Fagopyrum cymosum* Meisn. - Perennial buckwheat. Common buckwheat is a foreign-fertilized entomophilous plant species that blooms for about 30 days, while Tatar buckwheat is a self-fertilized plant species. Tartar buckwheat contains more rutin (8.5%), which is why it is important as a medicinal plant in folk medicine (Glamočlija *et al.* 2011; 2015). The most common variety in our country is 'Novosadska' buckwheat. It is a high-yielding and stable variety. Buckwheat grain yields vary greatly and depend on the genotype, agro-ecological conditions of production and harvesting

method. In hilly and mountainous areas, 1,000 kg ha^{-1} of buckwheat fruit can be produced, and in the best conditions, up to 3,000 kg ha^{-1}. Grain is used in the diet, while buckwheat flowers are an excellent bee pasture and an important source of nectar and pollen for bees. Bee plants can significantly contribute to stronger bee colonies and more economical beekeeping. That is what gives buckwheat additional value from the aspect of horticulture and beekeeping (Ikanović *et al.* 2012; Popović *et al.* 2013a; 2013b; 2014a; 2014b; 2017; 2019; 2020; 2021). Buckwheat production is of great importance. Buckwheat is cultivated for honey and for grain, for organic cultivation and for healthy foods. For bee grazing, it can be sown successively in five terms. Traditionally, milled buckwheat can be used for pasta, for blended bread and for different types of other flour dishes. The key issue is to design and develop functional foods with the aim of improving the state of health and well-being, and to reduce the risk of certain diseases (Scientific concepts, 1999). Many positive physiological effects are associated with buckwheat, it has no gluten, and is safe for patients with celiac disease (Skerritt, 1986). Buckwheat can synthesise rutin, an antioxidant that stimulates the human cardiovascular system (Vojtíšková *et al.* 2012). Buckwheat groats contain an important amount of resistant starch (Skrabanja and Kreft, 1998; Skrabanja et al., 1998) and could thus be useful in preventing colon cancer. Flattened metabolic responses, as described by glycemic and insulinemic indices after the ingestion of buckwheat meals, have recently been confirmed (Skrabanja *et al.* 2001; Kreft and Skrabanja, 2002). In different parts of the buckwheat plant and groats (Park *et al.* 2000) found appreciable amounts of rutin, a metabolite that antagonizes the increase of capillary fragility associated with hemorrhagic disease or hypertension in man (Schilcher *et al*. 1990). Honey is a natural, sweet substance they produce honey bees (*Apis mellifera*) processing plant nectar, or from juices from living parts of plants, or by collecting the excrement of the insects they feed on squeezing juices from living parts of plants,which bees collect, process and add their own specific substances, dehydrate and deposit in honeycomb cells until maturation (Rulebook on the quality of honey and other bee products, 2015). Buckwheat honey is dark amber to dark purple in color, full of nutrients, minerals, and vitamins, and has a strong taste. In favorable meteorological conditions, bees produce up to 300 kg of honey from one hectare of buckwheat (Popović *et al.* 2017). This paper analyzes the buckwheat and buckwheat honey production which has medicinal effects, due to increasing consumer demands for buckwheat as a functional food and its importance is pointed out in medicine.

MATERIALS AND METHODS

Production parameters of buckwheat production and honey natural in period 2016-2020 are analyzed in this paper. Data on buckwheat production are taken from the FAO, 2022. The results were processed using descriptive statistics and presented tabular and graphically. The need of buckwheat, for nutrition elements, depends on its chemical composition and the removal of nutrients with the harvest.

In Serbia, the most common variety is 'Novosadska' buckwheat can be successfully grown in mountain and plain conditions and achieves high yields. The grain yield of the 'Novosadska' variety varies 1.5-3 t $ha^{-1}$and the honey yield amounts and more than 300 kg ha^{-1} (Popović *et al.* 2022). Buckwheat requires 90 kg of nitrogen, 50 kg of phosphorus, and 150 kg of potassium to produce a yield of 2 t/ha. Before flowering, it consumes up to 60% nitrogen and potassium, 40% phosphorus, and the remaining nutrients — during the flowering-maturation period. The root system of buckwheat is able to absorb phosphates in a hard-to-dissolve form, which should be taken into account when setting fertilizers application standards (Glamočlija *et al.* 2015; Popović *et al.* 2017).

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RESULTS AND DISCUSSION

Buckwheat seed and honey production

The total buckwheat areas in world for the 2020. was 1,856,913.0 ha, grain yield 975 kg/ha and production 1810816.0 t, table 1, Figure 1. The largest sown areas under buckwheat were in Russia, followed by China, Ukraine, Kazakhstan, Poland, Japan, Brazil, France etc. In Serbia buckwheat was harvested about 200 ha, but the official statistics did not register Popović *et al.* 2017).

In world honey natural production was on average 1,770,119.0 t, in Europa 388,902.0 t and in EU 217,864.0 t, Table 1. In the total world honey production, Europe is a significant producer, with a share of 22%, while EU countries with 12.3%, figure 2.

Table 1. Average values buckwheat and honey production, t, in world, 2020

Parameter	Buckwheat production in World		
	Area, mill. ha	Yield, kg ha^{-1}	Production, mill. t
2020	1856913.0	975.0	1810816.0
Parameter	Honey natural production, mill. t		
Year	World	Europe	EU
2020	1770119.0	388902.0	217864.0
Share, %	100.0	22.0	12.3

Source: FAO 2022

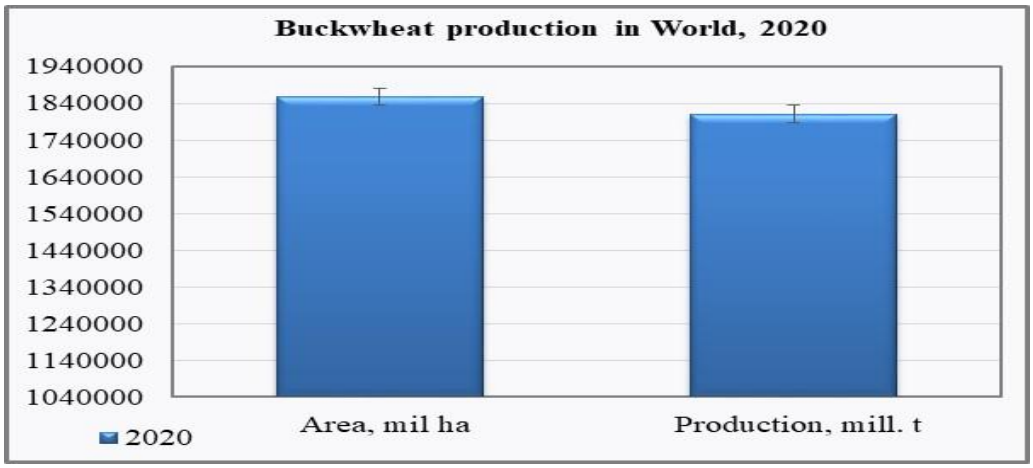


Figure 1. Buckwheat area (mill. ha) and production (mill. t) in world, t

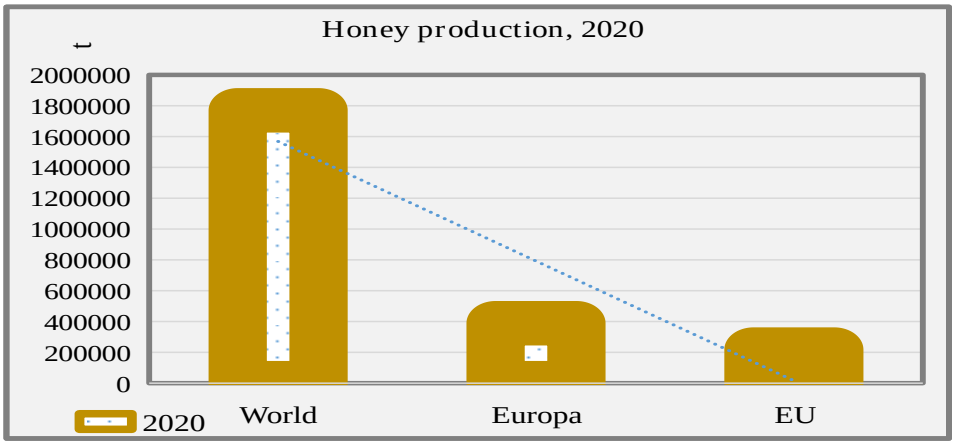
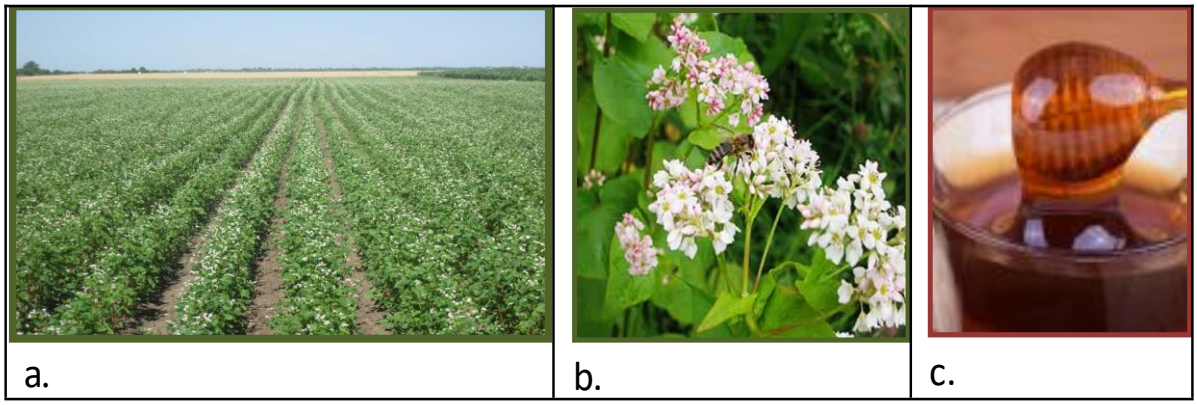


Figure 2. Honey production in world, t

Buckwheat 'Novosadska' variety the grain ripens in 80-110 days. In our agro-ecological conditions, the optimal time for sowing the 'Novosadska' variety is mid-April. Sowing is done at 25 cm with a grain seeder. The plants bloom for over 30 days, it blooms successively, and is an excellent bee pasture. The grain has a characteristic, angular shape and dark color with typical patterns. Harvesting with a grain harvester. The grain yield of the 'Novosadska' variety is up to 2 t/ha and the honey yield is about 200-400 kg/ha. Average yields of fresh buckwheat biomass are 25-35 t ha^{-1}, Pictures 1a and 1b. Buckwheat honey is dark amber to dark purple in color, full of nutrients, minerals, and vitamins, and has a strong taste, Picture 1c.

Buckwheat grain contains: carbohydrates (about 73%), proteins (12%), fats (2%), organic acids and rutin, minerals (potassium (446 mg), phosphorus (283 mg), calcium (115 mg), magnesium, sodium, iodine, zinc, bromine and iron, vitamins (D_2-ergokalciferol and D_3-holekalciferol, P-bioflavonoids and group B, B_3-niacin). Variety 'Novosadska' had the highest level of phenolic acids, proanthocyanidins, flavones, and most of the flavonols. 'Novosadska' buckwheat had a high antioxidant capacity, with 82% neutralizing radicals (Glamočlija *et al.* 2015). Buckwheat flowers are full of nectar and are they are excellent bee pasture, Figures 3a, 3b.



Picture 1. Variety 'Novosadska' buckwheat, a., flower, b., and buckwheat honey, c.
Source: Popović, 2022

Buckwheat honey is dark color, which it gets from polyphenols. Polyphenols is antioxidants, organic compounds which affect the quality of food, especially the color and taste, and contribute in improving nutritional characteristics. Antioxidants are substances that can protect cells from the damage caused by free radicals. Buckwheat honey is highly valued for its healing properties, and is full of nutrients, minerals, vitamins, and has a strong taste. In accordance with the law on food safety, the interests of consumers must be ensured the highest level of protection. The health benefits are known due to phenolic compounds, rutin, hesperetin, p-coumaric acid and 20 phenolic acids, including p-hydroxybenzoic and p-coumaric acids. Phenolic antioxidants from honey are bioavailable and increase the antioxidant activity of plasma. Buckwheat honey has a beneficial effect on bronchitis and cough, hypertension, arteriosclerosis, of heart disease, liver and intestinal diseases and has antibacterial effects (Popović *et al*. 2022).

Buckwheat nutrition value

Buckwheat nutrients, proximate composition (g/100 g grain) are as follows: energy (355 Kcal), total carbohydrates (73 g), total fiber (18 %), crude protein (12 %), moisture (11%), fat (7.4 g), fiber (17 g), *essential amino acids* (% of total protein) is: leucine (6.7%), lysine (5.9%), valine (4.7%), phenylalanine (4.2 %), methionine (3.7 %), isoleucine (3.5 %), threonine (3.5 %), histidine (2.2 %), cystine (2.2 %), tryptophan (1.4 %), *minerals* in mg/100g grain is: potassium (K, 450mg), magnesium (Mg, 390mg), phosphorus (P, 330mg), calcium (Ca,

110mg), iron (Fe, 4mg), manganese (Mn, 3.4mg), zinc (Zn, 0.8 mg), *vitamins* (mg/100 g grain) is: B_3-Niacin (18 mg), B_2-Riboflavin (10.6 mg), B_1-Thiamine (3.3 mg), B_4-Choline (440 mg), Tocopherols (40 mg), (Glamočlija *et al*. 2011; 2015; Joshi *et al.* 2019, Sindhu and Khatkar, 2019), B_5-Pantothenic acid, 2.14 mg; B_6-Piridoxin, 0,36 mg; B_9-Folate, 51.01 mg).

Medicinal use of buckwheat products

Buckwheat is a bitter but pleasant tasting herb (table 2, pictures 2a, 2b) that is frequently used medicinally because the leaves are a good source of rutin. Rutin (quercetin-3-rutinosid) is useful in the treatment of a wide range of circulatory problems, it dilates the blood vessels, reduces capillary permeability and lowers blood pressure. The leaves and shoots of flowering plants are acrid, astringent and vasodilator. It is used internally in the treatment of high blood pressure, gout, varicose veins, chilblains, radiation damage etc. It is best used in conjunction with vitamin C since this aids absorption. Often combined with lime flowers (*Tilia species*), it is a specific treatment for haemorrhage into the retina. The leaves and flowering stems are harvested as the plant begins to flower and are dried for later use. They should be stored in the dark because the active ingredients rapidly degrade in the light. A poultice made from the seeds has been used for restoring the flow of milk in nursing mothers. An infusion of the herb has been used in the treatment of erysipelas (an acute infectious skin disease). A homeopathic remedy has been made from the leaves. It is used in the treatment of eczema and liver disorders (http://www.naturalmedicinalherbs.net/herbs/f/fagopyrum-esculentum=buckwheat.php).

Buckwheat protein is of outstanding quality and, unlike popular cereals, is rich in essential amino acid, lysine. Health benefits of this plants include reducing plasma cholesterol level, anti-inflammatory, neuroprotective, anti-cancer, anti-diabetic effects and enhancing hypertension symptoms. Buckwheat is also used in gluten free diet in people with celiac disease and used in the alleviation of other common disease. It has also been recognized that buckwheat has a prebiotic and antioxidant activity (Noreen *et al.* 2021).

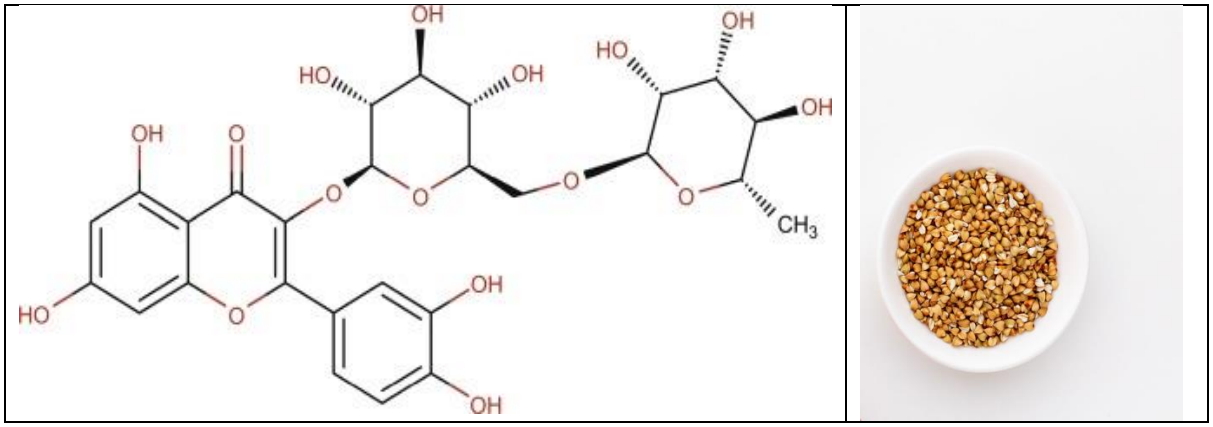
Table 2. Medicinal effects of Buckwheat honey

Honey aroma, content and used		Buckwheat honey used	
Honey aroma	Buckwheat honey has very nice strong specific aroma and malty.		Buckwheat honey is used to treat: ✧ It helps prevent atherosclerosis
Honey content	✧ Is rich in antioxidants ✧ Immune support ✧ Is rich is vitamins ✧ High protein content ✧ High mineral content ✧ Is very rich in iron.		✧ Anaemia ✧ Relieve heartburn ✧ It helps treat diseases of the digestive system ✧ Some liver diseases.
Used	Buckwheat honey is often used as a natural cardio tonic		✧ Helps reduce cholesterol ✧ Boosting antioxidants ✧ immunity
	As an effective cough medicine.		✧ It helps prevent dry cough ✧ Anti-viral and anti-fungal properties

The bioactive compounds in buckwheat are flavonoids (i.e., rutin, quercetin, orientin, isoorientin, vitexin, and isovitexin), fatty acids, polysaccharides, proteins, and amino acids, iminosugars, dietary fiber, fagopyrins, resistant starch, vitamins, and minerals. Buckwheat possesses high nutritional value due to these bioactive compounds. Additionally, several essential bioactive factors that have long been gaining interest because these compounds are beneficial for healing and preventing several human diseases (Huda *et al*. 2021).

The discovery and development of novel multi-targeted agents to attenuate the dysregulated signaling in cancer is of great importance. In recent decades, phytochemicals from dietary and medicinal plants have been successfully introduced as alternative anticancer agents due to their ability to modulate numerous oncogenic and oncosuppressive signaling pathways (Nouri *et al.* 2020).

Rutin (also known as rutoside, quercetin-3-O-rutinoside and sophorin) is an active plant-derived flavonoid that is widely distributed in various vegetables, fruits, and medicinal plants, including asparagus, *buckwheat*, cannabis plant, *grapes***,** apricots, apples, cherries, grapefruit, plums, oranges, figs and green or black tea, picture 2a.



Picture 2. Rutun structural-chemical formula, a., Rutin in medicinal plants, b.
Source: Popović, 2022

Rutin is a bioflavonoid which is used for blood vessels treatment. The greatest concentration of rutin was determined in blossoms (83.6 mg/g)and leaves, and (69.9 mg per g), roots (3,6 mg/g), stalks (0.5 mg/g) and the lowest concentration of rutin was found in buckwheat products: the value of rutin concentration in buckwheat groats, in flour, and in peels (0.1 mg/g). Tea mixtures with leaves and blossoms used for vessel diseases treatment (Vojtíšková *et al.* 2012).

Buckwheat honey has a beneficial effect on bronchitis and cough, hypertension, arteriosclerosis, liver and intestinal diseases, and has antibacterial effects against *Staphylococcus aureus* and *Pseudomonas aeruginosa*, strengthening the body's immunity and resistance. Potassium is an essential mineral that supports the functioning of nerves, muscles, and the heart in the body, while betaine helps with liver function and reduces the risk of heart disease. Buckwheat honey has a hepatoprotective effect and inhibits DNA damage, activities that are primarily attributable to its high antioxidant capacity. Wisconsin buckwheat honey has bactericidal activity against antibiotic-resistant pathogens (thirteen pathogens including: four *Clostridium difficile*, two Methicillin-resistant *Staphylococcus aureus*, two *Pseudomonas aeruginosa*, one Methicillin-Susceptible *Staphylococcus aureus*, two Vancomycin-resistance Enterococcus, one *Enterococcus faecalis* and one *Klebsiella pneumoniae*), including Clostridium difficile. Henriques *et al.* (2011) point out that the bactericidal activity of honey is not solely due to the presence of high sugar content and that

varying potent antibacterial compounds in honey may work synergistically to extensively disrupt cells and lysis of pathogens.

CONCLUSIONS

Buckwheat is a gluten-free pseudo-cereal that is used as a functional food, especially in people with celiac disease. Health buckwheat benefits are the following: reducing plasma cholesterol level, anti-inflammatory, neuroprotective, anti-cancer, anti-diabetic effects and enhancing hypertension symptoms. Buckwheat has a prebiotic and antioxidant activity. Buckwheat honey has a bactericidal mode of action against the pathogens and antioxidant, anti-inflammatory and anti-hyaluronidase properties which vary depending on the nectar source. Buckwheat can also act in the prevention and treatment of hypertension and hypercholesterolemia and it could be in preventing colon cancer.

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