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TEA AND HEALTH – A REVIEW OF THE CURRENT STATE OF KNOWLEDGE

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ABSTRACT

Until recently, tea has been numbered among stimulants, i.e. products of no nutritional value. Nowadays, with advance of research studies, the amount of data suggesting beneficial effect of tea on health is increasing. Polyphenols are the basic tea ingredients to which positive effect on human body is attributed. Their wide spectrum of biochemical activity, including a strong antioxidant potential, contributes to the situation in which tea may have various beneficial functions in the body. Research studies focus mostly on green tea which is believed to reduce the risk of many modern diseases. However, so far the preventive effect of tea has not been confirmed yet. Despite it being a natural product, too much tea in a diet carries the risk of excessive caffeine intake and decreased absorption of non-heme iron which may be of detrimental consequences for some groups of consumers.

KEY WORDS: *tea, polyphenols, caffeine, health*

INTRODUCTION

Tea is considered to be one of the most popular beverages. It is estimated that the mean consumption of tea per inhabitant worldwide amounts to 120 mL/day while for the Great Britain, which since centuries is famous of afternoon tea and high consumption of tea, it is 540 ml per day on average (1). In Poland, 76-90% of population drinks tea with the majority consuming 2-3 cups in a day (2).

Tea is produced from leaves, buds or delicate stems of the plant of genus *Camellia*. Dependent on the manufacturing process, three main types of tea may be enumerated, different in terms of flavour, colour and composition, i.e. green tea which is not subject to fermentation, oolong tea which undergoes semi-fermentation and black tea which results from full fermentation of plant. So far, the highest percentage of worldwide production and consumption has been attributed to black tea (ca 80%), which is very popular in North America and Europe and then to green tea which is mainly consumed in China and Japan (3, 4).

In folk medicine of Asian countries, tea was considered to be a medicine effective for many ailments. Furthermore, drinking tea was treated as a ceremony and philosophy of life (4, 5). Nowadays, tea and its impact on health attracts the attention of public and

literature provides optimistic data regarding tea's beneficial impact on cardiovascular system, reduction of body mass and even decreasing the risk of cancer and neurodegenerative diseases (3, 6).

The objective of the paper is to present the current data regarding the nutritional value of tea and its effect on health.

NUTRITIONAL VALUE OF TEA

The sugar free tea infusion is of no energetic value. Consequently, the amount of tea in a diet does not affect the daily calories intake. The energetic value of sweetened tea is dependent on the type of sugar substitutes used. The tea sweetened with table sweeteners does not provide calories while a cup of tea with a teaspoon of sugar or honey added has ca 20 kcal. Tea is a good source of ingredients having physiological properties, including polyphenols, caffeine and certain minerals.

Polyphenols

Having regarded the climate conditions of tea cultivation, including insolation and humidity as well as the age of picked leaves, the concentration of polyphenols in tea leaves varies. Their concentration in young tea leaves is higher compared to older ones which

are picked later. The type of polyphenols and their properties are associated with tea manufacturing process. Green tea contains mainly catechins while black tea - tannins, produced from catechins as the result of biochemical changes in the fermentation process. Having considered the concentration of catechins in green tea, the most predominant is epigallocatechin gallate (EGCG) which constitutes more than 50% of the total amount of catechins. This compound, compared to other catechins, is of the highest antioxidant potential. Thus, it is considered to be the most biologically active substance (3, 7-9).

From the nutritional perspective, the important issue is the amount of polyphenols in tea infusion intended for consumption. Besides the natural amount of polyphenols in tea leaves, their concentration may be highly affected by the process of infusion, including the amount of tea used for a cup, water temperature and brewing time. From the studies regarding the extent of polyphenols extraction in the infusion transpires that their highest concentration (170 mg/L) is observed in teas brewed for 10 minutes. Such infusions, however, are not preferred by consumers due to the worse organoleptic properties, especially bitterness, resulting from high concentration of polyphenols (10). According to the European Food Safety Authority (EFSA), 100 ml of green tea infusion contains 126 mg of catechins. In the light of data of Food and Drug Administration (FDA), such amount of green tea contains 71 mg of epigallocatechin gallate (11, 12). Other authors state that a cup of black tea provides 200 mg of flavonoids (9).

A lot of data support the statement that green tea is the most optimal source of catechins among the food products, followed by chocolate, red grapes, wine and apples (4). The American Heart Association recommends the Americans to increase the consumption of flavonoids, including those contained in tea. So far, however, no recommendations regarding the amount of polyphenols in a diet have been issued (13).

Caffeine

Tea, accompanied by coffee and cocoa seed, is the main vegetable source of caffeine. Caffeine is a methylxanthine of group of alkaloids, belonging to psychoactive substances. Its action consists in stimulating the central nervous system and cardiac action, which may positively affect the psychophysical capacity of a human (2). In teas such as *Camellia sinensis* and *Camellia assamica*, caffeine predominates (ca 90%) over other methylxanthines. However, there are also teas, e.g. *Camellia ptilophylla*, which contain high amount of theobromine (6%), thus, they are called cacao tea. The concentration of caffeine in tea leaves ranges from 2 to 5%, with higher values observed in young tea leaves (5).

The concentration of caffeine in tea infusions is dependent on the amount of tea used for a cup as well as brewing conditions, including water temperature and brewing time. The extraction efficiencies of caffeine from tea leaves is assessed at 61–85% (14). Having considered the multitude of factors, the concentration of caffeine in a cup of tea ranges from 14 to 65 mg (15). The highest concentration of caffeine is present in teas which are brewed for a long time. The studies on the caffeine concentration in black teas, purchased on the Warsaw markets, revealed that a cup of tea brewed for a short time (15 seconds), one minute and long time (5 minutes) provides 15, 22 and 34–38 mg of caffeine, respectively (16). EFSA states that a cup of black tea, brewed for 3–5 minutes, contains 40–45 mg of caffeine (11).

Having considered the caffeine concentration in black and green tea infusions, the study results vary. Several authors claims that the caffeine concentration in green tea is twofold lower compared to black tea while others state that their concentration is comparable (16, 17).

Furthermore, the study results on caffeine concentration in tea bags and loose leaf tea infusions are not coherent either. Pursuant to the certain results, caffeine extraction from tea bags is 30% poorer compared to loose leaf teas which results in lower concentration of caffeine. Others claim that the tea bags infusion is of higher caffeine concentration due to higher fragmentation of tea leaves (4). The studies conducted in Poland did not reveal any disparities between the caffeine concentration in both types of teas (16, 17).

Minerals

Dry tea leaves contain numerous elements such as fluoride, manganese, chrome, selenium, calcium, magnesium and zinc. Their concentrations are highly differentiated, ranging from 25 to 1000 µg/g and dependent on many factors, including conditions of cultivation, fermentation and even leaves size (4). From the nutritional perspective, however, more important is the concentration of these elements in tea infusions intended for consumption. Having considered the amount of tea required for preparation of tea infusion and extraction of minerals, tea infusion is not a good source of calcium, zink and magnesium in a diet. According to the country data, 100 ml of tea provides 0.07 mg of zink, 2 mg of magnesium and 5 mg of calcium which means that a cup of tea covers only 1-1.5 % of recommended daily intake of these elements in adults (18).

The situation is different in case of fluoride and manganese which are highly prevalent in tea infusions. The fluoride concentration in 100 ml of infusion, prepared using non-fluoridated water is 0.15 mg on average (1). Thus, a cup of tea covers 7-10% and 25-30% of

the daily intake of this element in adults and children, respectively. Having considered manganese, the western countries data specify that the concentration of this element in tea infusion ranges from 0.17 to 0.66 mg/100 ml of green tea and from 0.08 to 0.51 mg/100 ml of black tea (19, 20). According to the country tables of food nutritional value, 100 ml of tea infusion contains 0.34 mg of manganese on average (18). Due to its high concentration in tea, it becomes a major source of manganese in a diet of persons who drink tea. In the Great Britain, the average consumption of manganese in persons drinking ≥ 1 litre of tea per day was assessed at 5.5–10 mg, while in persons who do not drink tea – manganese consumption was 3.2 mg on average. In case of high consumption of strong tea, the intake of manganese may achieve Tolerable Upper Intake Level, which for adults was established at 11 mg/day (4, 19). Irrespective of high intake of manganese with tea, the clinical trials do not reveal significant differences in its concentration in blood and expression of Mn-dependent enzymes in persons who drink tea and non-tea drinkers (19). It may suggest that the organism is able to sustain quite constant concentration of manganese (homeostasis of manganese) as well as the lack of direct impact on its concentration in organism with higher intake in a diet.

Remaning ingredients

Tea belongs to the products containing significant amount of oxalates. These compounds form insoluble salts with minerals. Consequently, they hinder their absorption and increase the risk of nephrolithiasis. The concentration of oxalates in tea infusions is highly dependent on water temperature and brewing time. The study of Jabłońska-Ryś revealed that the concentration of oxalates in teas brewed in the temperature of 100 °C for 5 minutes ranged from 2.5 to 6.57 mg/100 ml of infusion. Green teas, brewed in lower temperature (75°C) contain lower concentration of oxalates compared to teas prepared with boiling water (21).

Tea infusion also contains small amounts of niacin (0.1 mg/100 ml) and folates (5 µg/100 ml) which compared to the average daily requirement does not constitute their significant source in a diet (18). According to Spanish data, tea provides 3-5% of daily intake of vitamins C and E in this population. However, Polish data suggest that tea infusion does not contain aforesaid vitamins (4, 18).

The leaves of tea contain also polysaccharides (13%), fats (3%), amino acids (4%), including mainly L-theanine, which as the data suggest may have a positive effect on mental capacity. However, the literature does not provide information on concentration of these compounds in tea infusions. A separate group of tea ingredients constitute numerous aromatics, saponins and colour additives (1, 11).

TEA AND HEALTH

For the last 20 years, tea was an object of many researches considering its health benefits. However, it has not been determined yet whether conventional amount of tea in a diet is of prophylactic properties (5, 6). The hypothesis regarding health-oriented effect of tea is based on the high concentration of polyphenols which increase the antioxidant potential of blood and thus can protect cells and tissues from detrimental effects of oxidation (9). Besides antioxidant activity, anti-inflammatory properties are also attributed to polyphenols consisting in stimulating the immune system, decreasing the absorption of cholesterol in blood and having positive effect on intestinal microflora by inhibiting the colonization with pathogenic bacteria (1, 22).

In the worldwide literature regarding the impact of tea on health, the publications from the Asian countries predominate, where the most popular is green tea and the data on black tea is considerably less abundant.

Green tea

Such type of tea is characterized by high concentration of catechins which are of stronger antioxidant potential compared to tannins present in black tea. From the epidemiological studies transpires that persons who drink more than 2 cups of green tea per day have lower concentration of total cholesterol and LDL cholesterol, which is also confirmed by the results of meta-analysis of randomized clinical trials. The authors claim that it may be interpreted into 22-33% lower risk of death due to cardiovascular diseases. Thus, drinking green tea is considered to be an element of prophylaxis of heart diseases (23). Having referred to other data, only higher consumption of green tea – at least 7 cups per day may have a prophylactic effect on cardiovascular diseases. However, it is emphasized that this assumption requires further studies (3).

Furthermore, the relation between drinking tea and progression of cancer has not been determined yet. Several studies involving animals suggest the beneficial effect of tea on decreasing the risk of cancer. However, it should be considered that tea dose or its ingredients administered to animals determined by body mass in kg are much higher compared to those consumed by humans (24). One of the argument cited in the literature, which confirms the effect of green tea on carcinogenesis is the low percentage of lung cancers in Japan. Japanese who smoke tobacco to a larger extent compared to Americans, develop lung cancer significantly more rarely which may result from disparities in green tea consumption between these populations (22).

Having referred to the progression of stomach cancer, the current literature provides two meta-analyses of

epidemiological studies. From one of them transpires that drinking 5 cups of green tea per day may have a protective effect. Nevertheless, the authors emphasized that these results should be interpreted cautiously due to the presence of numerous life style factors affecting the progression of disease (25). The second meta-analysis suggests that persons who drink high amount of green tea (5-10 cups per day) do not suffer from stomach cancer less frequently compared to those who drink its small amount (1-2 cups per day) (26).

Several studies regarding the effect of tea on cancer focus on the correlation between green tea consumption and colorectal cancer. Some of them suggest that drinking green tea may have a slight effect on decreasing the risk of this cancer occurrence while others do not reveal any relation (1, 27). Such situation is also observed in case of breast and prostate cancer. According to the Food and Drug Administration, the study results are so ambiguous that based on the current state of knowledge it is not feasible to acknowledge that green tea may decrease the risk of aforesaid cancers (12).

The studies conducted in Chinese population indicate that drinking tea may slightly protect from Parkinson's disease. The mechanism of such action has not been recognized, however, it is presumed that it may result from the action of polyphenols and caffeine which increase the circulation of blood in brain. These conclusions are of such initial nature that nowadays they are exclusively subject to scientific deliberations (28, 29).

Several studies suggest that green tea reduces the body mass as the effect of the action of caffeine and epigallocatechin gallate which decrease the absorption of fat, increase the energetic expenditure and burning of adipose tissue (4, 7-8, 23). Pursuant to some epidemiological studies, persons who drink more than 400 ml of tea per day for many years (mainly green tea) have lower body mass and waist circumference compared to non-tea drinkers. Contrary conclusions are drawn from the meta-analysis of randomized clinical trials which suggests that in patients who were administered catechins and caffeine derived from green tea for 12 weeks, the observed reduction of body mass was inconsiderable (<0,5 kg) and statistically insignificant (7). Irrespective of the contrary results, some experts claim that drinking green tea may be considered as an element of prevention of obesity. Since years, producers use the ingredients derived from green tea for the production of weight loss supplements (8). However, here a fact should be mentioned. Based on the evaluation of studies results intended to issue health-oriented statements regarding the food, EFSA claimed that the beneficial effect of caffeine on body mass has not been scientifically proved. The works of EFSA concerning the assessment of health aspects of teas and polyphenols are in progress.

Black tea

Black tea is not subject to analyses to such an extent as green tea is. However, it may be presumed that some properties of green tea can also be referred to black tea with the example being the effect of tea on reduction of body mass resulting from caffeine action. If some studies suggest that green tea reduces the body mass, then it should be remarked that it does not contain higher concentration of caffeine than black tea. Thus, such action should be associated with these two types of teas.

The beneficial conclusions are also drawn from the relations between drinking black tea and heart action. From the review of epidemiological studies transpires that drinking at least 3 cups of black tea per day reduces the risk of cardiovascular diseases which results mainly from the presence of polyphenols, mainly tannins (1).

The meta-analysis of epidemiological studies also presents interesting and optimistic data which specify that drinking at least 4 cups of tea per day (irrespective of its type) may reduce the risk of type 2 diabetes by 20% (30). Similar results were obtained for coffee. However, in both cases, it is not linked with the concentration of caffeine but polyphenols (31).

SAFE TEA AMOUNT IN A DIET

Tea which is consumed in conventional amounts does not negatively affect the human health. It may have detrimental affects when tea consumption in a diet is high. It results from excessive absorption of caffeine and polyphenols binding non-heme iron which reduce its absorption in the gastrointestinal tract even by 79%. Polyphenols which are present in black tea, especially tannins inhibit the absorption of iron to a larger extent compared to catechins of green tea. Thus, persons diagnosed with iron deficiency anaemia or being at risk of developing anaemia should refrain from consuming tea, especially black tea at meals (1, 4, 5). Having considered its effect on decreasing the absorption of iron, black tea is recommended in a diet of persons with haemochromatosis in which the excessive accumulation of iron is observed.

From the perspective of caffeine, the safe amount of tea is dependent on the consumption of other products such as coffee, cola or energy drink. In the light of current state of knowledge, the safe consumption of caffeine by healthy adults and children aged up to 12 years should not exceed 400 mg per day and 2.5 mg/body mass in kg/day, respectively. Provided there are no other sources of caffeine in a diet, an adult could even consume several cups of tea.

Several experts claim that having considered the concentration of caffeine, its diuretic properties

observed with the high consumption as well as the unfavourable effect on iron absorption, the maximum consumption of black tea should not exceed 8 cups per day (1).

SUMMARY

Tea is a natural, low-processed and calorie-free beverage. Thus, it is much better for the majority of population, including children compared to sweetened and carbonated beverages. Drinking tea is not only pleasurable but also may have beneficial effect on health by strengthening the antioxidant potential of human organism.

The study results in this respect are promising but they should be interpreted cautiously as the tea infusion composition is affected by many factors. Irrespective of that fact, nowadays the producers of food are increasingly interested in tea extracts intended to be used for functional food.

In the light of current state of knowledge, it may be presumed that green tea is of higher nutritional value compared to black tea. However, the irrefutable arguments indicating which type of tea is the most optimal and what is their effect on health are still to be uncovered in the future.

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