REVIEW

This paper is dedicated to the 70th anniversary of the founding of Physiologia Bohemoslovaca (currently Physiological Research)

The Anti-Obesity and Health-Promoting Effects of Tea and Coffee

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Summary

This paper reviews provenance, chemical composition and properties of tea (Camelia sinensis L.) and coffee (Coffee arabica, L. and Coffea canephora, L.), their general health effects, as well as the currently available knowledge concerning their action on fat storage, physiological mechanisms of their effects, as well as their safety and recommended dosage for treatment of obesity. Both tea and coffee possess the ability to promote health and to prevent, to mitigate and to treat numerous disorders. This ability can be partially due to presence of caffeine in both plants. Further physiological and medicinal effects could be explained by other molecules (theaflavins, catechins, their metabolites and polyphenols in tea and polyphenol chlorogenic acid in coffee). These plants and plant molecules can be efficient for prevention and treatment of numerous metabolic disorders including metabolic syndrome, cardiovascular diseases, type 2 diabetes and obesity. Both plants and their constituents can reduce fat storage through suppression of adipocyte functions, and support of gut microbiota. In addition, tea can prevent obesity via reduction of appetite, food consumption and food absorption in gastrointestinal system and through the changes in fat metabolism.

Key words

Obesity • Adipocyte • Tea • Coffee • Metabolism • Food consumption

Introduction

Tea and coffee are the most popular drinks, the most highly traded and valued commodities that originates from the developing world. Their global consumption is permanently increasing due to their sensory and health properties. They can help in preventing and combatting obesity – the current world’s pandemics. World’s leading cause of death are diseases related to metabolic dysfunctions. The most significant in this aspect is overweight, which affects 1.9 billion of people around the world, of whom 650 millions are obese (Haider and Larose 2019). Obesity and overweight can facilitate diabetes, cause inflammations, cardiovascular and reproductive diseases as well as cancer (Skrypnik et al. 2017, Sung et al. 2018). In addition to these health risks, they are a cause of mobility issues, as well as problems in social and sexual relationships. They lower self-esteem and the overall quality of life. They also lead to considerable economic losses. Health care concerning patients with obesity incurs at least 25 % higher expenditures and causes losses of 1-3.6 % of the gross domestic product of a country (Mohamed et al. 2014). Prevention and treatment of diseases using natural products and functional food of plant origin have always been the basis of folk and oriental medicine. Nowadays, they are experiencing a renaissance and their popularity is growing even in the official medicine and self-treatment. Coffee and tea could be promising candidates for prevention and treatments of various diseases including obesity.
Provenance and properties

**Tea**

Tea tree (Camellia sinensis, L.) is a bush or a small tree from the Theaceae family grown in tropic and subtropical regions around the world. In Southeast Asia, the most common cultivar is Camellia sinensis sinensis, in India and on Ceylon - Camellia sinensis assamica. Based on the processing method (fermentation in the presence of bacteria or oxidation) and the taste, colour, aroma and biological effect of the tea, we recognize white, green, matcha, black, oolong, and Puerh tea (Rothenberg et al. 2018, Tang et al. 2019).

Despite most of Europe and the New World being accustomed to black tea, more antioxidants and tannins are present in non-oxidated and non-fermented white and green teas (Prasadh et al. 2019) and they also have a stronger benefit to health.

From the standpoint of biology and medicine, the most important are tea metabolites – alkaloid theobromine, its metabolite caffeine (1,3,7 trimethylxantin) and polyphenols (theaflavins), catechins – epigallocatechin, epicatechin and their metabolites epigallocatechin gallate, epicatechin gallate, gallicatechs and gallocatechin gallate. Gallates contain biologically active ethers of gallic acid. Tea contains also smaller amounts of other biologically active polyphenols – quercetin, kaemperol and myricetin. Black tea contains also polyphenolic compounds theaflavins and thearubigins (Saeed et al. 2019). In addition to that, tea contains microelements borate, cobalt, copper, iron, manganese, molybdenite and lead (Karaoğlu et al. 2017), pigments, polysaccharides, alkaloids, free amino acids, and saponins (Tang et al. 2019).

**Coffee**

Coffee plant (Coffea spp.) is a short tree or a bush native to Africa, the fruits of which are red coffee “cherries.” For preparation of drinks, two coffee species are used – Coffee arabica, L. (Arabica coffee) and Coffea canephora, L. (Robusta coffee). The best-known molecule in this fruit is alkaloid methylxanthine caffeine (1,3,7 trimethylxantin) – a toxin, which protects the plant from herbivores. In addition to caffeine, coffee fruit contains alkaloid trigonelline, polyphenol chlorogenic acid, ferulic acid, diterpenes cafestrol and kahweol, melanoidins and coffee lipids and microelements (Ludwig et al. 2014, Islam et al. 2018, Stefanello et al. 2018).

Positive effects on human health

**Tea**

Polyphenols of green tea are efficient against chronic inflammatory conditions of liver, gastrointestinal tract, and against neurodegenerative diseases (Oz 2017). Anti-inflammatory effect of polyphenols can be explained by their action on gastrointestinal microbiota, which is responsible for immune responses (Yang et al. 2016).

Tea molecules at the right ratio counteract anxiety and stress (Unno et al. 2018). A link has been determined between green tea consumption and memory of older men. It is peculiar that the memory of older women was not affected (Xu et al. 2018).

Tea catechins can have an anti-tumour effect. They inhibit multiplication of cells, trigger their apoptosis (death) and autophagy and reduce vitality of cancer cells (Singh et al. 2018). They can even enhance the therapeutic effects of medicine against tumour diseases and simultaneously mitigate their adverse side-effects (Cao et al. 2016, Bedrood et al. 2018).

Most studies carried out on animals and humans report that tea (extract from tea tree leaves) reduces manifestations of metabolic syndrome, diabetes and cardiovascular diseases (including reducing the risk of heart attack) (Yang et al. 2018). Other studies demonstrated positive effect of tea on decreasing insulin in blood, but not on the concentration of glucose, triacylglycerols, fatty acids and hormones of adipose tissue (Mielgo-Ayuso et al. 2014, Li et al. 2016). Yang et al. (2016), however, reported that the reduced glucose levels in blood can be caused by the action of green tea polyphenols on glucose production in liver.

**Coffee**

Clinical studies demonstrated that the ability of coffee to reduce blood sugar is not dependent on caffeine but on its other components (Tunnicliffe and Shearer 2008). This effect probably comes from chlorogenic acid. Chlorogenic acid has antioxidant and anti-inflammatory effects, it can affect metabolism of glucose and lipids. Thanks to its antioxidant, anti-inflammatory and metabolic effects, coffee and its molecule chlorogenic acid have a preventive and therapeutic influence against diabetes, cardiovascular diseases, tumours, inflammation, lipidation of liver and Parkinson disease (Ludvig et al. 2014, Tajik et al. 2017, Islam et al. 2018, Perumpail et al. 2018). Their consumption can be recommended not only to healthy people but also to people with high cholesterol.
and blood glucose, with hypertension, metabolic syndrome (Sarría et al. 2018, Xie et al. 2018) or diabetes (Tunnicliffe and Shearer 2008). Anti-diabetic effects were determined not only for chlorogenic acid but also for other acid components of coffee – caffeine and ferulic acid (Islam et al. 2018).

Large-scale studies showed a correlation between the habit of drinking coffee and reduced mortality linked to cardiovascular diseases, reduced risk of heart attacks and diabetes. Contrary to a popular belief, drinking coffee was not linked to increased occurrence of cardiac arrhythmias (Bhatti et al. 2013). Thanks to the ability of coffee’s antioxidants to bind free radicals (Yashin et al. 2014), drinking coffee was not linked to increased occurrence of cardiac arrhythmias (Bhatti et al. 2013). Thanks to the ability of coffee’s antioxidants to bind free radicals (Yashin et al. 2013) and to reduce diseases and mortality, coffee earned the title “longevity beverage” (Bhatti et al. 2013).

**Anti-obesity effects**

**Tea**

All performed studies (with the exception of Mielgo-Ayuso et al. 2014) validated the ability of tea and its components to reduce fat stores and body weight of humans (Huang et al. 2014, Janssens et al. 2016, Li et al. 2016, Pan et al. 2016, Vázquez Cisneros et al. 2017, Rothenberg et al. 2018, Yang et al. 2016, 2018).

This effect was achieved thanks to polyphenols (Pan et al. 2016, Silvester et al. 2019). According to the existing data, epigallocatechin and caffeine from tea leaves have independent mechanisms of effect but synergic effect on weight loss (Janssens et al. 2016, Türközü and Tek 2017, Vázquez Cisneros et al. 2017).

According to some sources, black tea polyphenols are more efficient than green tea polyphenols (Pan et al. 2016), but other authors report evidence of stronger effect of green tea (Yang et al. 2016).

It is presupposed that tea molecules reduce fat stores through several pathways (Huang et al. 2014, Pan et al. 2016, Yang et al. 2016, Rothenberg et al. 2018, Silvester et al. 2018, Willems et al. 2018):

- they influence neuroendocrine metabolic regulators of appetite and reduce food consumption (Huang et al. 2014),
- they reduce emulsion and absorption of lipids and protein in gastrointestinal system and consequently reduce calorie intake (Huang et al. 2014, Pan et al. 2016),
- they act on gastrointestinal microbiota (lactobacilli and bifidobacteria), which are responsible for digestion. For example, they produce short fatty acids, which increase the rate of lipid metabolism (Yang et al. 2016, Rothenberg et al. 2018),
- they inhibit the differentiation and proliferation of preadipocytes, (Pan et al. 2016),
- they reduce lipid production (Huang et al. 2014, Yang et al. 2016),
- they promote lipolysis and lipid metabolism (Pan et al. 2016, Yang et al. 2016),
- they stimulate conversion of white adipose tissue to brown, increase its oxidation, burning and expenditure of energy through heat production (Huang et al. 2014, Silvester et al. 2018, Willems et al. 2018),
- they promote fecal lipid excretion (Huang et al. 2014).

However, it is necessary to take into consideration that the effect of green tea and its molecules manifests only when large doses are consumed. Vázquez Cisneros et al. (2017) recommended a daily dose of 100-460 mg of epigallocatechin gallate plus 80-300 mg of caffeine a day over the course of 12 and more weeks. Yang et al. (2016, 2018) recommended 3-4 cups of strong tea (600-900 mg of catechins) a day for at least 8 weeks minimum (Yang et al. 2018).

**Coffee**

The results of in vitro and animal studies suggest that coffee can reduce storing of fat in the body by several mechanisms:

- It inhibits multiplication of adipocytes (Pan et al. 2016),
- It influences transcription factors and other proteins involved in production of lipids in these cells (Tamura 2020),
- Through action on gastrointestinal microbiota, which can also affect obesity (Pan et al. 2016).

Thanks to these effects, coffee can reduce fat stores in obese animals and humans (Hasani-Ranjbar et al. 2009, Onakpoya et al. 2011, Pan et al. 2016, Ríos-Hoyo and Gutiérrez-Salmeán 2018, Tabrizi et al. 2019, Tamura, 2020) and reduce body weight of humans (Hasani-Ranjbar et al. 2009, Onakpoya et al. 2011, Pan et al. 2016, Tabrizi et al. 2019). A study of Sarría et al. (2018) determined a positive effect of green and roasted coffee on metabolic indexes but not on body weight of patients.
Possible adverse side-effects

**Tea**

Tea consumption at a dose of 3 cups a day (Karak et al. 2017) or epigallocatechin gallate at a dose of 300 mg a day over the course of 12 weeks (Mielgo-Ayuso et al. 2014), or 704 mg epigallocatechin gallate a day (Hu et al. 2018) had no significant adverse side-effects. No cytotoxic and genotoxic, mutagenic, carcinogenic and embryotoxic effects of green tea were determined either (Bedrood et al. 2018).

Consumption of tea polyphenols can have a toxic effect on liver (Mazzanti et al. 2015) especially when consumed on empty stomach (Bedrood et al. 2018), or as pills rather than as beverage (Ho et al. 2018). Some studies reported the ability to caffeine to affect negatively the reproductive system – damage DNA, reduce sperm capacity and prolong pregnancy (Ricci et al. 2017).

**Coffee**

Caffeine in large doses can cause anxiety, insomnia, loss of calcium from the body and consequent increased risk of fractures, especially in people with osteoporosis (Bhatti et al. 2013). Possible negative effects of caffeine on brain development and development of reproductive organs in embryos and children have not been excluded (Islam et al. 2018). There are indications that caffeine and coffee can damage sperm and prolong pregnancy (Ricci et al. 2017). Cafestrol and kahweol can increase blood cholesterol levels (de Roos et al. 1999). Despite these findings, large-scale studies found no statistically significant effect of coffee and caffeine consumption on the occurrence of health complications in adults, pregnant women, adolescents and children (Doepker et al. 2018) and conversely, they determined positive effect on health and longevity (see above).

General evaluation and recommendations

**Tea**

Tea belongs to humankind’s favourite beverages. It has many positive effects on health. It is applied in prevention and treatment of a number of diseases. In Japan, green tea is added to everything including desserts and ice cream. Influence of tea on body weight reduction is conclusively validated by science. Considering its effects, it is possible to recommend it as a method of weight loss stimulation or an ingredient in food with added value. All types of tea have a positive effect on health and weight reduction. In medication, tea can be substituted by its functional components – epigallocatechin gallate and caffeine mixed at a given ratio.

However, it is necessary to remember that the effects of tea will manifest only at large doses (3-4 cups of strong tea a day, which represents 1-2 g of tea containing 100-600 mg polyphenols) and long-term use. Minimum length of the treatment is 8 weeks. For those not used to drink large amounts of tea, there is an alternative – condensed tea or its pure components. However, in that case its adverse side-effects on liver and reproductive system cannot be excluded.

**Coffee**

Scientific results validate coffee extract’s application for weight loss and treatment of some metabolic disorders (diabetes, obesity, etc.). Coffee has a number of other positive physiological effects on health and longevity. Adverse side-effects of coffee are not serious and they manifest only when consumption is excessive. This knowledge allows to recommend coffee extract as an ingredient in a beverage intended for weight loss.

At present, the market offers numerous kinds of coffee. Naturally, a question arises as to which are the most efficient for weight reduction and at what dose.

**Is green coffee better for weight loss then roasted?**

During roasting of green coffee, so called Mallard Reaction metabolizes chlorogenic acid to antioxidant melanoid, which is responsible for the biological activity of this acid (Tunnicliffe and Shearer 2008, Dybkowska et al. 2017). Green coffee contains fewer antioxidants and polyphenols than roasted (Odžaković et al. 2016). This means that roasting increases rather than reduces the metabolic effects of coffee.

**Is decaffeinated coffee better for weight loss?**

Decaffeination decreases the antioxidant activity of coffee (Yashin et al. 2013). Tunnicliffe and Shearer (2008) proved that positive effects of coffee are not dependent on caffeine at all but instead on other components. Therefore, in relation to weight loss the presence or absence of caffeine in your coffee makes no difference.
How much coffee to drink for weight reduction?

One strong cup of coffee contains 60 mg of pure chlorogenic acid. This dose has essentially no effect on absorption of chlorogenic acid into the body (Williamson et al. 2011). Metabolic effect is achieved at daily intake of minimum 510.6 mg of chlorogenic acid and 121.2 mg of caffeine (Sarriá et al. 2018). In Canada, considered a safe dose for adults are 400 mg of caffeine for one-time dose (Doepker et al. 2018). Drinking 5 cups of coffee a day had only positive effects on health (Carlström et al. 2018).

This evidence speaks in favor of roasted coffee extract with about 400 mg of caffeine and/or 510 mg of chlorogenic acid, which corresponds 3-5 cups of strong coffee a day to be used for weight reduction. This amount can be considered a metabolically efficient as well as safe dose. For those who cannot manage so many coffees a day, coffee can be replaced by an adequate amount of chlorogenic acid and caffeine.

Conclusion

Both tea and coffee possess the ability to promote health and longevity, as well as to prevent, to mitigate and to treat numerous disorders including obesity and obesity-related illnesses (Bhatti et al. 2013). This ability can be partially due to presence of caffeine in both plants. Further physiological and medicinal effects could be explained by other molecules, which are different in these plants, but which can have common antioxidant properties. The physiological effects of tea, besides caffeine, can be explained by presence of theaflavins, catechins, their metabolites and polyphenols quercetin, kaempherol and myricetin, whilst the physiological effects of coffee are probably related to caffeine and polyphenol chlorogenic acid (see above). Due to anti-oxidant and anti-inflammatory properties these plant molecules can be efficient for prevention and treatment of numerous metabolic disorders including metabolic syndrome, cardiovascular diseases, type 2 diabetes and obesity. Both plants and their constituents can prevent and reduce fat storage through suppression of adipocyte functions and support of gut microbiota. In addition, tea can prevent obesity via reduction of appetite and reduce food consumption and food absorption in gastrointestinal system and changes in fat metabolism.

It is necessary to keep in mind, that the anti-obesity effects of both tea and coffee can be expressed only by intensive consumption of large amounts (3-6 cups of strong drink daily).

Conflict of Interest

There is no conflict of interest.

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