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Original Article

Concentrations and solubility of selected trace metals in leaf and bagged black teas commercialized in Poland

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ABSTRACT

The objective of this study was to determine the concentrations of heavy metals in bagged and leaf black teas of the same brand and evaluate the percentage transfer of metals to tea infusion to assess the consumer exposure. Ten leaf black teas and 10 bagged black teas of the same brand available in Poland were analyzed for Zn, Mn, Cd, Pb, Ni, Co, Cr, Al, and Fe concentrations both in dry material and their infusion. The bagged teas contained higher amounts of Pb, Mn, Fe, Ni, Al, and Cr compared with leaf teas of the same brand, whereas the infusions of bagged tea contained higher levels of Mn, Ni, Al, and Cr compared with leaf tea infusions. Generally, the most abundant trace metals in both types of tea were Al and Mn. There was a wide variation in percentage transfer of elements from the dry tea materials to the infusions. The solubility of Ni and Mn was the highest, whereas Fe was insoluble and only a small portion of this metal content may leach into infusion. With respect to the acceptable daily intake of metals, the infusions of both bagged and leaf teas analyzed were found to be safe for human consumption.

1. Introduction

Tea is one of the most popular beverages all over the world. About 18–20 billion cups of tea are consumed daily worldwide; therefore, there is an economic and social interest in tea [1–3]. Consumption of tea in Poland is about 0.7–1.5 kg/person per year. It is the second (after water) most consumed beverage in Poland [4]. The health benefits of tea have been well documented [2,5]. However, consuming tea may provide also a significant contribution for intake and accumulation of trace metals in the human body, which was not fully studied. Although tea is considered a healthy beverage, we should keep in mind its potentially toxic effects, which have been neglected in the past [1].

Tea is made from dried leaves of a shrub, *Camellia sinensis* [6]. Production of black tea involves plucking, indoor withering, leaf disruption, fermentation, and drying [7]. The last

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stage involves sorting the leaves into grades according to their sizes (whole leaf, broken leaf, fannings, and dust). Whole leaves are of the highest quality, followed by broken leaves, fannings, and dusts. Whole leaf teas have a coarser texture than bagged ones and are considered the most valuable. Broken tea leaves are usually sold as medium-grade loose teas or, together with fannings and dusts, can be manufactured for use in tea bags [8]. The final composition, aroma, color, and taste of tea depend on the processing stages and degree of fermentation [9]. However, only a few studies have focused on the comparison of concentrations in different types of teas of the same brand.

The leaves of *Camelia sinensis* are a source of mineral elements such as zinc, manganese, iron, copper, magnesium, titanium, aluminum, strontium, bromine, sodium, potassium, phosphorous, iodine, and fluorine. The tea infusion contains small amounts of proteins, vitamins, and carbohydrates but may be a source of metals and metal binding polyphenols [2,10]. The regular consumption of tea may contribute to the daily requirements of some elements. Some metals found in tea (e.g., Fe, Mn, Zn) are components of important enzymes or participants in a number of physiological processes so they are considered essential for the proper functioning of the human body [10–12]. However, some of the other elements are undesirable or toxic to human health, such as As, Cr, Cd, Co, Ni, and Pb [10,13–15]. Previous studies showed that tea can be rich in trace metals classified as human carcinogens by the International Agency for Research on Cancer. These are, in particular, Cd, Co, Cr, and Ni [13,16–18]. Determination of trace metals in tea is important for two reasons: to evaluate their nutritional value and to guard against any probable harmful effects they may cause to human consumers [3,6,10].

Tea infusion can be a reliable dietary source of major and trace elements because, while brewing, elements included in tea leaves are differentially extracted into infusions. The amount of elements that can get into the human body depends on the following parameters: total content in dry tea, characteristics of water used for brewing, fraction of the total content extracted to the infusion, and bioavailability of the element from the beverage [6,19].

In the present study, it has been hypothesized that bagged black tea contains higher amounts of trace metals than leaf tea of the same brand and that the trace metal content in infusion made from bagged tea is higher than made from leaf tea. Therefore, the type of tea chosen by consumers is important in view of intake of toxic metals. To verify the hypothesis, concentrations of Zn, Mn, Cd, Pb, Ni, Co, Cr, Al, and Fe in black tea samples and in tea infusions were determined and compared. The objective of the study was to evaluate the percentage transfer of the elements tested to the infusion and determine the concentrations of trace metals available in bagged tea and leaf black tea of the same brand.

2. Materials and methods

Ten commercial leaf black teas and 10 commercial bagged teas of the same brand from well-known tea trading companies were purchased at local stores in Wrocław, Poland, in March 2013 (Table 1). The procedure described by Dambiec et al [20] was followed for the preparation of samples for analysis of metal concentrations in dry teas and tea infusions.

Prior to analysis, five infusion bags were randomly selected from each box of tea, and their contents were mixed. Samples of both bagged and leaf teas were dried at 50°C to constant weight and ground into fine powder in a laboratory mill IKA Labortechnik M20 (Staufen, Germany) to obtain a representative sample.

Table 1 – Description of studied brands of commercially purchased black teas.

Tea type	Tea sample	Name	Producer/importer	Origin	Steeping time (min)[a]
Bagged tea	1	Tetley classic	TATA Global Beverages Polska Sp. Z o.o., Poland	Indefinite origins	3
	2	Lloyd tea ceylon	Mokate S.A., Poland	Sri Lanka	4–5
	3	Dilmah ceylon gold	MJF Holdings Ltd., Sri Lanka	Sri Lanka	3–5
	4	Sir Roger yunnan	Roger Sp. z o.o., Poland	China	3–5
	5	Posti yunnan	Posti S.A., Poland	China	4–6
	6	Lipton yellow label tea	Unilever Polska Sp. z o.o., Poland	Indefinite origins	1–2
	7	Ahmad tea English No.1	Ahmad tea Ltd	Sri Lanka	
	8	Posti ceylon	PH-W "POSTI" S.A., Poland	Sri Lanka	4–6
	9	Oskar black tea bags yunnan style	Oskar International Trading Sp. Z o.o., Poland	China	—
	10	Irving daily classic	Amber Spark S.A., Poland	Indefinite origins	2–3
Leaf tea	11	Tetley classic	TATA Global Beverages Polska Sp. Z o.o., Poland	Indefinite origins	3
	12	Lloyd ceylon	Mokate S.A., Poland	Sri Lanka	5–7
	13	Dilmah ceylon gold	MJF Holdings Ltd., Sri Lanka	Sri Lanka	3–5
	14	Sir Roger yunnan	Roger Sp. z o.o., Poland	China	3–5
	15	Posti yunnan	Posti S.A., Poland	China	4–6
	16	Lipton yellow label tea	Unilever Polska Sp. z o.o., Poland	Indefinite origins	3–5
	17	Ahmad tea English No.1	Ahmad Tea Ltd., UK	Sri Lanka	4–6
	18	Posti ceylon	PH-W "POSTI" S.A., Poland	Sri Lanka	4–6
	19	Oskar gold yunnan black tea	Oskar International Trading Sp. z o.o., Poland	China	3–5
	20	Irving daily superior	Amber Spark S.A., Poland	India	3–5

[a] According to the instructions given by tradesmen.