

**INTAKE OF TANNIC ACID FROM TEA AND COFFEE
AS A RISK FACTOR FOR LOW IRON BIOAVAILABILITY
IN PREGNANT WOMEN**

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Summary

Introduction: Iron binding polyphenols are widespread in foods because they occur naturally in a variety of cereals, vegetables, and spices, and in many beverages such as wine, coffee, and tea. These beverages strongly inhibit nonheme iron absorption. Pregnancy presents a critical period for both woman and child, and iron blood status of a pregnant woman is especially important since its adverse impact on pregnancy outcomes.

The aim was to determine the intake of tea and coffee, and intake of iron binding polyphenols from these beverages (expressed as tannic acid equivalents) in pregnant women.

Participants and Methods: A consumption of tea and coffee was noted by 24-hour dietary recall in a population of pregnant women (N = 222).

Results: Total of 153 pregnant women (68.9 %) were drinking either coffee, tea or both during pregnancy. Tea was consumed by 18.0 % (n = 40), and in much higher percentage coffee, by 58.6 % (n = 130) of pregnant women. Total intake of tannic acid equivalents from tea and coffee was the highest in the 2nd trimester (median of 15.0 mg/day), while for the 1st and the 3rd trimester median was 11.0 mg/day. This is in compliance with the findings that physiologic changes during pregnancy lead to avoidance of consumption. During the 1st trimester 20 coffee drinkers and 7 tea drinkers gave up their preferred beverage due to nausea. At the 3rd trimester 20 out of 113 pregnant women who drank only coffee (17.7%) and 6 out of 23 who drank only tea (26.1 %) stopped drinking a particular beverage, referring heart-burn as a reason.

Conclusion: Even though for some pregnant women physiology of pregnancy leads to lowering consumption or absolute avoiding of preferred beverage, coffee and tea are highly consumed among pregnant women and can be considered as an important factor for low iron bioavailability.

Keywords: tannic acid, tea, coffee, pregnant women.

Introduction

Everyday foods mostly have low iron content and low bioavailability because of large number of factors inhibiting iron absorption. Therefore, iron deficiency anaemia is common even in developed countries, in which no restriction of food exists. Iron in foods is present as heme and nonheme, differing mainly by absorption level. Overall iron absorption is low, only 10 to 20 % of total iron intake is absorbed (Boulpaep and Boron, 2006), but rises if the iron deficiency anaemia is presented. Heme iron from animal foods is well absorbed

(20 – 40 %), while prevailing iron, nonheme iron from plant foods has low absorption (1 – 10 %) because of many inhibiting factors (Thompson, 2007; Tapiero et al, 2001; Milman, 2006; Zimmermann and Hurrell, 2007).

Since iron intake is closely related to energy intake (6 mg of iron per 1000 kcal), risk of iron deficiency is especially pronounced in cases when iron needs exceed energy needs like in case of pregnancy where the recommended intake rises up to 27 mg per day (Zimmermann and Hurrell, 2007; IOM, 2002; Boulpaep and Boron, 2006; Berger et al 2011; Wheeler, 2008).

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Absorption of nonheme iron is restricted to duodenum, and its solubility is crucial. Nonheme iron is present in ferri (Fe^{3+}) or fero (Fe^{2+}) form. Ferri form forms insoluble complexes and is not promptly absorbed, and asks for pH below 3. Unlike it, fero form is readily absorbed even up to pH 8 (Boulpaep and Boron, 2006; Lynch, 1997).

Iron bioavailability is under the influence of different factors which either promote or inhibit iron absorption (Hallberg and Hultén, 2000; Hoppe et al, 2008; Heath et al, 2000; Zhou et al, 2005; Thompson, 2007; FAO/WHO, 2001). Ascorbic acid is probably one of the most known promoting factor, and meat proteins by its so called meat factor. On the other hand, spectrum of inhibiting factors lower iron absorption: phytic and oxalic acid, starch, polyphenols (i.e. tannins of coffee and tea), egg white, calcium, other minerals (e.g. zinc), and numerous drugs which inhibit gastric excretion (e.g. antacids) (Andrews, 2006; Hallberg and Hultén, 2000; Zimmermann and Hurrell, 2007; Milman, 2006; Thompson, 2007; Tapiero et al, 2001).

Coffee and tea are very common and daily consumed beverages. They contain large amount of phenolic compounds (galic and tannic acid) and they are usually consumed with meal or right after meal. One cup of tea (cca 200 ml) reduces iron absorption by 75 – 80 %, depending on amount, type and preparation. A cup of coffee (cca 150 ml) reduces absorption by 60 %. When coffee and tea are consumed with meal containing 100 g of meat, iron absorption is inhibited by 50 %. If the phenolic content is taken, it is expected that coffee reduces iron absorption even more, but on the other hand, coffee stimulates gastric excretion, promoting iron solubility. Surely, strong coffee can inhibit iron absorption in even higher rate, as well as tea (black tea shows the highest inhibition rate) (Hallberg and Hultén, 2000; Hurrell et al, 1999; Morck et al, 1983). Still, adding milk to either tea or coffee does not further increases rate of inhibition (Hurrell et al, 1999). If the coffee is consumed 1 hour before meal no change in iron absorption is present, and on the other hand if it is consumed 1 hour after a meal, rate of inhibition is equal (Morck et al, 1983).

Iron deficiency anaemia is the most common nutritional disorder around the globe. It presents mayor public health problem. Nutritional deficiency is

the main cause for developing countries. For developed countries it develops as a result to gastrointestinal or genitourinary bleeding (McPhee et al, 2006; WHO, 2001). Never the less, in developed countries nutritional intake of iron should be considered, its adequacy as well as bioavailability, especially if it is a matter of one of the risk groups; pregnant women, infants (especially low birth weight or preterm infants), adolescents and women of reproductive age.

Incidence of anaemia is especially high during pregnancy and lactation due to increased needs for iron (Scholl, 2011; Lee et al, 2002; Tapiero et al, 2001). It is of utmost importance to monitor iron status and iron intake during pregnancy since iron deficiency anaemia presents risk factor for pregnancy outcomes, such as preterm delivery, small for gestation and low birth weight infants (Scholl, 2011; Lee et al, 2002; Zimmermann and Hurrell, 2007; Casanueva and Viteri, 2003; Viteri, 2011).

Therefore, the aim was to determine the intake of tea and coffee, and intake of iron binding polyphenols from these beverages throughout gestation. Also, the aim was to determine whether intake of iron binding polyphenols (expressed as tannic acid equivalents) show any correlation with the total intake of iron from foods.

Participants and Methods

To ensure randomized sample, inclusion criteria was healthy pregnancy within 12 weeks of gestation (i.e. 1st trimester), followed in general gynaecologist office from area of city Osijek. Early pregnancy was selected since statistical data for past several years show that for around 88 % of women pregnancy is confirmed within 12 weeks of gestation (ZZJZ, 2011; ZZJZ, 2010; ZZJZ, 2009). Overall, 222 pregnant women were recruited and followed through gestation at two general gynaecologist offices from area of city Osijek. The study was approved by the Ethical committee of Faculty of Food Technology Osijek; an informed consent was obtained for all participating pregnant women.

Basic data regarding age, education level, incomes and smoking habits of pregnant women at the beginning of 1st trimester were collected with short questionnaire. Medical scale (Seca, UK) was used

for the weight measurement (with the precision of ± 0.1 kg), and height measurement (with head in Frankfurt position with the precision of ± 0.1 cm). Body mass index (BMI) was calculated for all women and it was considered as pre-pregnancy BMI. World Health organization (WHO) criteria (WHO 2001) was considered for the classification of women as underweight (BMI < 19.0), normal weighted (BMI ranging from 19.0 to 24.9), overweight (BMI ranging from 25.0 to 29.9) or obese (BMI from 30.0 and more). Weight gain was followed and after the delivery it was compared to the recommended weight gain during pregnancy (IOM, 2009).

Nutrition quality assessment was done by 24-hour dietary recall in multi pass protocol, and was repeated once during each trimester. Computer program NutriPro which uses National Composition tables (Kaić-Rak and Antonić, 1990) was used to calculate energy intake and intake of macro and micronutrients, and the results were compared to the recommended intake in pregnant women (IOM, 2002). Intake of coffee and tea was calculated separately, and expressed as daily intake in millilitres. When daily intake of these beverages was calculated, by the recommendation from Hallberg and Hultén (2000) it was recalculated on tannic acid equivalents. The protocol was as follows (Hallberg and Hultén, 2000):

1 cup of coffee (150 ml) equals 15 mg of tannic acid,

1 cup of tea (200 ml) equals 30 mg of tannic acid. Statistical analysis was done with software tool Statistica 8.0 (StatSoft, Tulsa, OK, USA), at significance level $p = 0.05$. MS Office Excel (2007, Microsoft Corp., USA) was used for other calcula-

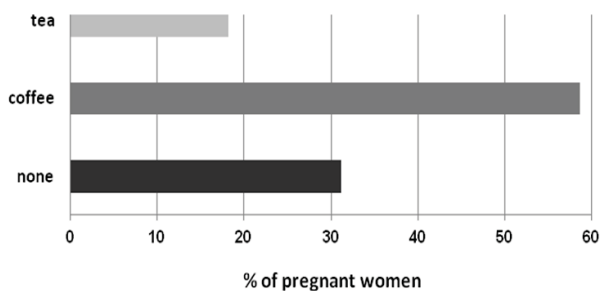


Fig. 1. Intake of beverages containing iron binding polyphenols among pregnant women during gestation (N = 222)
Slika 1. Unos pića koja sadrže željezo vezano polifenolima među trudnicama tijekom trudnoće (N = 222)

tions and graphs.

Results and Discussion

Total of 153 pregnant women (68.9 %) were drinking either coffee, tea or both during pregnancy (Fig. 1). Coffee is preferred in much higher percentage. 13 women simultaneously drank coffee

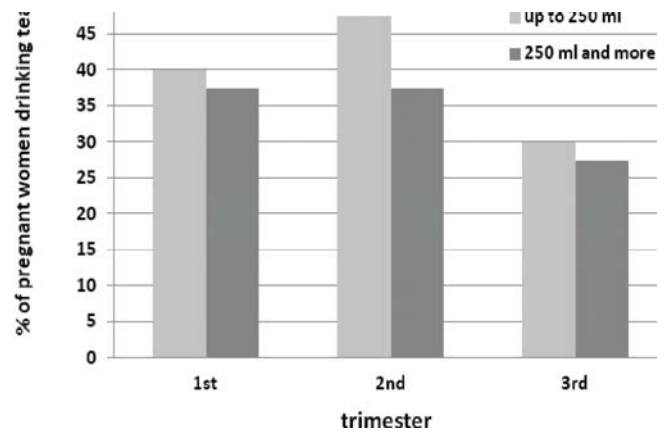


Fig. 2. Differences in tea intake during trimesters in pregnant women consuming tea (n = 40)

Slika 2. Razlike u unosu čaja tijekom tromjesečja u trudnica koje konzumiraju čaj (n = 40)

and tea, while 4 women combined drinking tea or coffee during particular trimester.

Tea was consumed by 18.0 % (n= 40) of pregnant women (Fig. 1), ranging from 250 ml up to 540 ml per day (Fig. 2). Mostly preferred were different fruit teas (such as blueberry, forest fruits), dog-rose, camomile and mint tea. Tea consumption shows similar consumption rate in low (up to 250 ml/day) and high consumption group (250 ml

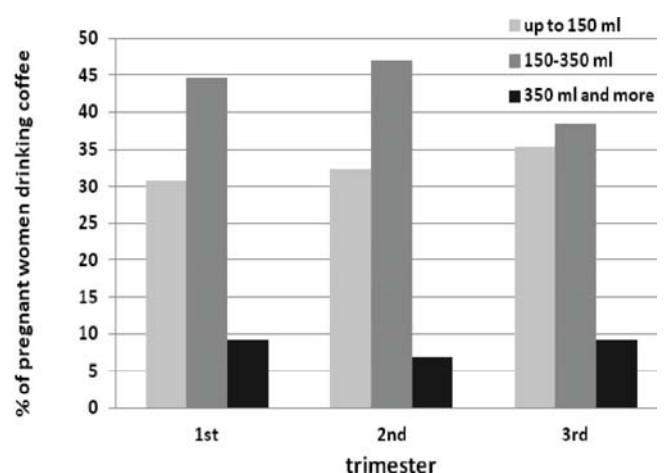


Fig. 3. Differences in coffee intake during trimesters in pregnant women consuming coffee (n = 130)

Slika 3. Razlike u unosu kave tijekom tromjesečja u trudnica koje konzumiraju kavu (n = 130)

and more/day) being the lowest in the 3rd trimester. Coffee was consumed in much higher percentage (**Fig. 1**), by 58.6 % (n = 130) of pregnant women, ranging from 100 ml up to even 600 ml per day, preferably as instant coffee. Coffee was consumed in quite high rate of 2 cups or more per day (150 – 350 ml/day) during all trimesters (**Fig. 3**). Still, unlike in tea consumers, coffee consumption in low (up to 150 ml/day) consumption group was higher in the 3rd trimester (rises up to 35.4%). While medium consumption group (150 – 350 ml/day) showed slight fall in consumption rate at the end of pregnancy (falls on 38.5 %), high consumption group (350 ml and more/day) showed U-shaped consumption curve, with the lowest consumption during the 2nd trimester (6.9 %). Possible explanation for these results lies in physiologic adaptations on pregnancy. Study participants did confirm this statement. During the 1st trimester 20 coffee drinkers and 7 tea drinkers gave up their preferred beverage due to nausea. At the 3rd trimester 20 out of 113 pregnant women who drank only coffee (17.7 %) and 6 out of 23 who drank only tea (26.1 %) stopped drinking a particular beverage, referring heart-burn as a reason. These results are also

in compliance to the results given in **Table 1**. Total intake of tannic acid equivalents from tea and coffee (**Table 1**) was the highest in the 2nd trimester (median of 15.0 mg/day), while for the 1st and the 3rd trimester median was 11.0 mg/day. All these results confirm earlier findings that physiologic changes during pregnancy (nausea in the 1st and heart-burn in the 3rd trimester) (Guyton and Hall, 2006; McPhee et al, 2006; Heidemann, 2005) lead to avoidance of consumption in a particular trimester (**Fig. 2 and 3**).

Average daily intake of iron from foods statistically significant rises through gestation (**Table 1**). Still, although intake follows rising trend from the 1st towards 3rd trimester, large part of participating pregnant women does not satisfy recommended intake for iron. Low intake of iron from foods in pregnant woman is in accordance to numerous researches (Lee et al, 2002; Milman, 2006; Shobeiri et al, 2006; Zhou et al, 2005; Petrakos et al, 2006). Since recommended daily intake of iron is 27 mg (IOM, 2002) daily intake of iron satisfies from 35.2% in the 1st trimester up to 41.5% in the 3rd trimester of the daily needs for iron in pregnancy

Table 1. Average daily intake of iron from foods and tea and coffee consumption in pregnant women during gestation (N = 222)

Tablica 1. Prosječan dnevni unos željeza iz hrane i čaja i kave u trudnica tijekom trudnoće (N =222)

	1 st trimester median (25 % - 75 %)	2 nd trimester median (25 % - 75 %)	3 rd trimester median (25 % - 75 %)	p*
total Fe (mg)	9.5 (7.5 – 12.4)	10.1 (7.8 – 13.3)	11.2 (8.7 – 14.6)	<0.001
tannic acid equivalents from coffee and tea (mg)	11.0 (0.0 – 22.0)	15.0 (0.0 – 22.0)	11.0 (0.0 – 20.5)	0.024

(**Table 1**). Similar results between iron intake and recommendations (around 60 % DRI) were reported by Shobeiri et al (2006).

When observing intake of iron from foods (**Table 1**) it is visible that nutrition quality of participating pregnant women does not differ much from nutrition of other women, in other terms, does not satisfy recommended intake, although researches have shown that pregnant women are more prone to changes in nutritional habits for better (Rifas-Shiman et al, 2009). This is the reason why supple-

mentation is recommended in terms of iron status control. Typical nutrition is low in iron and it has low bioavailability, and nutritional intake of iron is closely related to energy intake (Zimmermann and Hurrell, 2007; Hurrell and Egli, 2007; Thompson, 2007; FAO/WHO, 2001; WHO, 2001; Hallberg and Hultén, 2000).

Correlation coefficients show that tannic acid equivalents have significant impact on total iron intake during all trimesters (**Table 2**), placing these

Table 2. Spearman rank order correlations for tannic acid equivalents and total iron intake during trimesters among pregnant women consuming tea and coffee (n = 153)

Tablica 2. Spearman-ov koficijent korelacije za ekvivalent taninske kiseline i ukupnog unosa željeza tijekom tromjesečja kod dugotrajnog unosa čaja i kave u trudnica (n = 153)

		Tannic acid equivalents (mg)			Total iron (mg)		
		1 st	2 nd	3 rd	1 st	2 nd	3 rd
Tannic acid equivalents (mg)	1 st	1.000					
	2 nd	0.723	1.000				
	3 rd	0.402	0.502	1.000			
Total iron (mg)	1 st	0.222	0.259	0.258	1.000		
	2 nd	0.130	0.180	0.234	0.426	1.000	
	3 rd	0.092	0.056	0.133	0.194	0.368	1.000

beverages as important iron inhibiting agents. The consumption of these beverages in women having low iron intake present an important factor that affects iron bioavailability. This is in compliance to other findings that the consumption of iron binding polyphenols should be limited in pregnant women having iron deficiency anaemia or nutrition low in animal foods (Verbeke and De Bourdeaudhuij, 2007; Hallberg and Hultén, 2000; Thompson, 2007). Again, need for education is visible.

Conclusions

Intake of tea and coffee as the most important beverages containing iron binding polyphenols shows fluctuations in consumption that are related to physiologic changes during gestation (nausea in the 1st and heart-burn in the 3rd trimester). Still, their consumption shows correlation with the total iron intake, confirming these beverages as an important iron inhibiting agents. More emphasis should be given to education intervention programmes which could have long-term impact on proper nutritional habits in pregnant women and after the delivery, directly affecting adoption of these habits in children.

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UNOS TANINSKE KISELINE IZ KAVE I ČAJA KAO RIZIČNI ČIMBENIK ZA NISKU BIORASPOLOŽIVOST ŽELJEZA U TRUDNICA

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Sažetak

Uvod: Željezo vezujući polifenoli su široko rasprostranjeni u hrani obzirom da su prirodno prisutni u velikom broju žitarica, povrća i začina, te u velikom broju napitaka poput vina, kave i čaja. Ovi napitci pokazuju jaku inhibiciju apsorpcije nehemskog željeza iz hrane. Trudnoća predstavlja kritičan period i za ženu i za dijete, a status željeza u krvi trudnice je posebice važan zbog svog učinka na ishod trudnoće i/ili poroda.

Cilj ovog istraživanja bio je odrediti unos čaja i kave, te unos željezo vezujućih polifenola iz ovih napitaka (izraženih kao ekvivalenti taninske kiseline) u trudnica.

Ispitanice i metode: Konzumacija čaja i kave je bilježena putem 24-satnog prisjećanja u populaciji trudnica (N = 222).

Rezultati: Tijekom trudnoće je ukupno 153 trudnice (68,9 %) pilo kavu, čaj ili oba napitka. 18,0 % trudnica (n = 40) je konzumiralo čaj, dok je kava konzumirana u puno većem postotku, od 58,6 % (n = 130). Ukupan unos ekvivalenata taninske kiseline iz čaja i kave je bio najviši tijekom 2. tromjesečja (medijan od 15,0 mg/dan), dok je u 1. i 3. tromjesečju medijan iznosio 11,0 mg/dan. Ovi su rezultati u skladu s fiziološkim promjenama u trudnoći koji vode k izbjegavanju konzumacije ovih napitaka. Tijekom 1. tromjesečja 20 trudnica koje su pile kavu i 7 trudnica koje su pile čaj odreklo se svog preferiranog napitka zbog mučnina. U 3. tromjesečju je 20 od 113 trudnica koje su pile samo kavu (17,7 %) i 6 od 23 trudnice koje su pile samo čaj (26,1 %) prestalo piti određeni napitak, a kao razlog su navele probleme sa žgaravicom.

Zaključak: Iako za dio trudnica fiziologija trudnoće vodi k nižoj konzumaciji ili apsolutnom izbjegavanju preferiranog napitka, čaj i kava su visoko zastupljeni napitci među trudnicama i mogu se smatrati važnim čimbenikom za nisku bioraspoloživost željeza.

Ključne riječi: taninska kiselina, čaj, kafa, trudnica