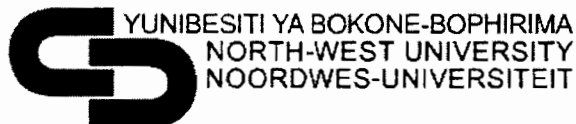


**The association between black tea consumption and iron  
status of African women in the North West Province:  
THUSA study**

**L Muller**

**B.Sc. Dietetics**

***Mini dissertation submitted in partial fulfilment of the requirements  
for the degree Magister Scientiae in Dietetics at the North-West  
University (Potchefstroom Campus)***



Supervisor: Dr SM Hanekom

2005

Potchefstroom

## Acknowledgements

I wish to express my sincere appreciation for the contribution the following people made towards my study:

- My parents for never giving up on me, understanding my frustrations and always being there with a comforting word and all the love and support in the world. Without their help (financially and emotionally) none of what I have achieved would have been possible.
- Pieter for being there when I needed him and understanding when I had to work as well as helping me with the figures in the study.
- Dr. Grieta Hanekom (supervisor) for all her guidance, support and encouragement during the past year.
- Dr Suria Ellis for her part in the statistical analysis and interpretation of the data.
- Ms. E. Uren for her assistance in the editing of the dissertation.
- My family for all their love and support.
- Lastly, my Heavenly Father for giving me so many blessings everyday and the ability to achieve far beyond what I think I'm capable of.

## **Afrikaanse titel en opsomming**

**Die verband tussen swart tee inname en ysterstatus van Swart vroue in die Noordwes Provinsie: THUSA studie**

### ***OPSOMMING***

**Motivering:** 'n Verskeidenheid van faktore insluitend voedseltekorte, swak higiëne en 'n lae opleidingsvlak dra by om die voedingstatus van swart vroue te beïnvloed. Vroue het verder 'n hoë risiko vir die ontwikkeling van ystertekorte aangesien hulle baie yster verloor deur menstruasie, die geboorteproses en 'n algemene lae inname van ysterbevattende voedsel. Al hierdie faktore dra by om die risiko vir die ontwikkeling van ystertekort anemie in vroue te verhoog.

**Doelwitte:** Die primêre doel van hierdie studie was om die assosiasie tussen tee inname en die ysterstatus van swart vroue in die Noordwes provinsie te ondersoek. Die meer spesifieke doelwitte om die primêre doel te bereik was om (1) die ysterstatus van vroue te bepaal (2) die tee inname te bepaal en (3) die verhouding tussen tee inname en yster status te bepaal terwyl die inhiberende en bevorderende faktore in gedagte gehou word.

**Metodes:** 'n Kruis steekproef van klaarblyklike gesonde vrouens uit 5 verskillende stratum van verstedeliking is geneem. Die populasie is verder verdeel in 2 groepe naamlik jonger vroue (jonger as 45.9 jaar) of ouer vroue (ouer as 46 jaar). Die steekproefgrootte was 920. Data is verkry van dieet, demografiese en bykomende vraelyste sowel as deur die insameling van bloedmonsters. Die studie is gedoen as deel van die THUSA studie.

**Resultate:** 'n Totaal van 920 proefpersone is ingesluit in die studie, waarvan 69.24% jonger vroue was en 30.76% ouer vroue. As gevolg van verlore data, het die hoeveelheid proefpersone vir elke parameter verskil. Die gemiddelde serum ferritien en hemoglobien waardes was binne normale grense vir beide groepe. Die gemiddelde dieetsterinname was minder as die dieetaanbevelings vir beide groepe. Geen betekenisvolle korrelasies is gevind tussen serum ferritien of hemoglobien en totale tee-inname sowel as 'n verskeidenheid van ander dieetfaktore nie. Die lae hemoglobienkonsentrasie groep van die jonger en ouer vroue het 'n effense hoër inname van dierlike proteiene en askorbiensuur gehad as die hoë hemoglobien konsentrasie groep. Die hoë serum ferritien konsentrasie groep het egter merkbare hoër inname van dierlike proteien gehad.

**Gevolgtrekking:** Die resultate van hierdie studie dui aan dat tee nie 'n inhiberende effek op die yster status van die vroulike populasie van die Noord Wes provinsie het nie. Daar is egter gevind dat ander studies wat op dieselfde onderwerp gedoen is, gemengde resultate het. Twee van die sewe studies wat ondersoek is, het aangedui dat tee geen inhiberende effek op ysterabsorpsie het nie. Hierdie twee studies, net soos die THUSA studie is nie uitgevoer in 'n gekontroleerde omgewing nie, met ander woorde faktore soos tyd van tee inname en gelyktydige inname van melk is nie gekontroleer nie. Die ander vyf studies is uitgevoer in 'n omgewing waar proefpersone maaltye ontvang het, die tyd van tee inname gekontroleer en melkinname aangedui is. Die gevolgtrekking kan dus gemaak word dat verdere studies in die Suid-Afrikaanse populasie, in 'n gekontroleerde omgewing, nodig is om betroubare aanbevelings aan die populasie te verskaf.

**Sleutelterme:** Absorpsie, biobeskikbaarheid, polyfenole, swart tee, ysterstatus, ystertekort, ystertekortanemie.

## English title and summary

The association between black tea intake and iron status of African women in the North West Province: THUSA study

### *Summary*

**Motivation:** A variety of factors including food shortage, poor hygiene and low education levels affects the nutritional status of black women. Women also have a high risk for the development of iron deficiency because they lose iron through menstruation, the birth process and a low intake of iron containing foods. All of these factors contribute to an increased risk for the development of iron deficiency anaemia in women.

**Objectives:** The primary purpose of the study was to investigate the association between tea consumption and iron status of African females in the North West Province. To reach this purpose the specific aims were to (1) assess the iron status of women, (2) determine tea intake, and (3) determine the relationship between tea consumption and iron status, taking into account inhibiting and enhancing factors of iron absorption.

**Methods:** A cross-sectional sample of apparently healthy females was taken from five different strata of urbanisation. The subjects were then further divided into two groups, namely younger women (younger than 45.9 years) and older women (older than 46 years). A sample of 920 subjects was used. Data were obtained from dietary, demographic and additional questionnaires, as well as from the taking of blood samples. This study was a sub-study of the THUSA study.

**Results:** A total of 920 subjects participated of which 69.24% were younger women and 30.76% were older women. Due to missing data, the number of subjects for each parameter differed. The mean serum ferritin as well as haemoglobin concentrations were within normal ranges for both groups. The mean dietary iron intake for both groups was below recommendations. No significant correlations were found between serum ferritin or haemoglobin and total tea intake as well as a variety of other dietary factors. The low haemoglobin concentration group of the younger and older women combined had a slightly higher intake of animal protein and ascorbic acid than the high haemoglobin concentration group. On the other hand, the high serum ferritin concentration group had a significantly higher intake of animal protein than the low serum ferritin concentration group.

**Conclusion:** The results of this study indicated that tea does not have an inhibitory effect on the iron status of the female population of the North West Province. However, the investigation of other studies conducted on the same topic had mixed results. Two of seven studies investigated and this study indicated that tea had no inhibitory effect on iron absorption. These two studies, as well as this study were not done in a controlled environment where certain factors can be controlled for, for example, time of tea intake and milk consumption with tea. The other five studies were, however, conducted in an environment where subjects were given test meals, time of tea consumption was regulated and milk consumption with tea was recorded. The conclusion can, therefore, be made that further studies on the South African population in a controlled environment are necessary to give accurate recommendations to the population.

**Keywords:** Absorption, black tea, bioavailability, iron status, iron deficiency, iron deficiency anaemia, polyphenols.

## **CONTENTS**

<b>ACKNOWLEDGEMENTS</b>	.....	<b>2</b>
<b>OPSOMMING</b>	.....	<b>3</b>
<b>ABSTRACT / SUMMARY</b>	.....	<b>5</b>
<b>CONTENTS</b>	.....	<b>7</b>
<b>ABBREVIATIONS</b>	.....	<b>10</b>
<b>FIGURES</b>	.....	<b>11</b>
<b>TABLES</b>	.....	<b>12</b>

### **CHAPTER 1: BACKGROUND AND MOTIVATION**

1.1	Introduction	.....	14
1.2	Problem formulation	.....	16
1.3	Hypothesis	.....	16
1.4	Objectives	.....	17
1.5	Definitions	.....	17
1.6	Outline of the study	.....	17

### **CHAPTER 2: LITERATURE REVIEW: IRON METABOLISM, BLACK TEA AND IRON STATUS, AND HEALTH EFFECTS**

2.1	Introduction	.....	20
2.2	UNICEF conceptual framework	.....	21

2.3	Iron in the body .....	23
2.4	Absorption of iron .....	24
2.4.1	Absorption of non heme iron .....	25
2.4.2	Absorption of heme iron .....	27
2.5	Iron deficiency .....	28
2.6	Factors leading to iron deficiency .....	29
2.6.1	Common causes of iron deficiency .....	29
2.6.2	Inhibiting factors in iron absorption .....	32
2.6.3	Enhancing factors in iron absorption .....	37
2.7	Summary .....	39
2.8	Chapter references .....	41

**CHAPTER 3: THE ASSOCIATION BETWEEN BLACK TEA CONSUMPTION AND IRON STATUS OF AFRICAN WOMEN IN THE NORTH WEST PROVINCE: THUSA STUDY.**

3.1	Abstract .....	48
3.2	Introduction .....	48
3.3	Methods .....	50
3.3.1	Subjects .....	50
3.3.2	Organizational procedures .....	51
3.3.3	Statistical analysis .....	52
3.3.4	Ethical considerations .....	53



3.4	Results .....	53
3.5	Discussion .....	63
3.6	Conclusion .....	67
3.7	Chapter references .....	68

**CHAPTER 4: GENERAL SUMMARY, RECOMMENDATIONS AND CONCLUSIONS.**

4.1	Introduction .....	72
4.2	Summary of main findings .....	72
4.3	Limitations .....	73
4.4	Recommendations .....	73
4.5	Conclusions .....	74

**Addendum 1:**

The impact of urbanization on physical, physiological and mental health of Africans in the North West Province of South Africa: the THUSA study (Vorster *et al.*, 2000)

**Addendum 2:**

Authors instructions for the South African journal of clinical nutrition

## **Abbreviations**

DNA	deoxyribonucleic acid
DRI	dietary reference intake
Fe	iron
IDA	iron deficiency anaemia
NCD's	non-communicable diseases
QFFQ	quantitative food frequency questionnaire
RDA	recommended daily allowance
THUSA	transition, health and urbanisation in South Africa
UNICEF	United Nations Children's fund
VIGHOR	Vanderbijlpark information project on health, obesity and risk factors

## Figures

Figure 1.1	Consider dietary iron deficiency in the patient with multiple risk factors <a href="http://www.vanderbilt.edu/.../IronDeficiencyAnemia.htm">www.vanderbilt.edu/.../IronDeficiencyAnemia.htm</a> (16 September 2005)	15
Figure 2.1	Conceptual framework for development of malnutrition (UNICEF, 1998)	22
Figure 2.2	Conceptual framework of causes of IDA (Van Lieshout <i>et al.</i> , 2004:7)	23
Figure 2.3	Normal iron absorption and metabolism <a href="http://www.cdc.gov/hemochromatosis/training/pathophysiology/iron_cycle_pop_up.htm">www.cdc.gov/hemochromatosis/training/pathophysiology/iron cycle pop up.htm</a> (16 September 2005)	25
Figure 2.4	Stages of iron deficiency and measurements of iron status (MacPhail <i>et al.</i> , 2004:12)	28
Figure 3.1	Percentage women in younger and older groups	55

## **Tables**

Table 2.1	Factors influencing dietary iron absorption (Hallberg, 2001:6)	25
Table 2.2	Foods most frequently consumed by South Africans (Steyn <i>et al.</i> , 2003:643)	31
Table 2.3	Summary of studies which investigated the effect of tea consumption on iron status	34, 35
Table 3.1	Dietary intakes and characteristics of the study population	54
Table 3.2	Dietary intakes and characteristics of younger and older women	55
Table 3.3	Spearman correlation coefficients between haemoglobin and serum ferritin for the study population	57
Table 3.4	Comparison of mean dietary intakes and standard deviations for the study population (younger and older women) between haemoglobin $\geq$ 12 or $<$ 12 as well as a comparison of dietary intakes with RDA and AI	58
Table 3.5	Comparison of mean dietary intakes and standard deviations for older women (between HB $\geq$ 12 or HB $<$ 12)	59
Table 3.6	Comparison of mean dietary intakes and standard deviations for younger women (between HB $\geq$ 12 or HB $<$ 12)	60
Table 3.7	Comparison of mean dietary intakes and standard deviations for the study population (younger and older women) between serum ferritin $>$ 12 or $<$ 12 as well as a comparison of dietary intakes with RDA and AI	61
Table 3.8	Comparison of mean dietary intakes and standard deviations for older women (between serum ferritin $>$ 12 or serum ferritin $<$ 12)	62
Table 3.9	Comparison of mean dietary intakes and standard deviations for younger women (between serum ferritin $>$ 12 or serum ferritin $<$ 12)	63

## Chapter 1:

### Background and motivation

# Chapter 1: Background and motivation

## 1.1 Introduction

In every living cell in the human body there is iron (Bruner, 1999:3). Iron plays a role in a variety of metabolic processes. Haemoglobin is responsible for oxygen transport from the lungs to the tissues and myoglobin for the transport and storage of oxygen in the muscles (Anderson, 2000:129). Iron also plays an important role in cellular respiration because of its oxidation/reduction capabilities (Conrad *et al.*, 1999:213; Wessling-Resnick, 2000:130). Other functions of iron include electron transport, oxidative degradation of drugs, conversion of hydrogen peroxide to oxygen and water, and involvement in cognitive performance and immune function (Anderson, 2000:130; MacPhail, 1998:137; Yip, 2001:330).

Iron deficiency not only causes anaemia but can also affect work capacity, neurotransmitter function and immunologic and inflammatory defenses (Ross, 2002:220, Wessling-Resnick, 2000:130). Some of the signs and symptoms of iron deficiency include glossitis (glistening appearance of tongue), angular stomatitis, spoon shaped nails and a pale conjunctiva (Beard *et al.*, 1996:306; Ross, 2002:222). Behavioural changes can occur, which include pica (compulsive eating of non food items) and pagophagia (compulsive eating of ice) (Andrews, 1999:1990; Ross, 2002:222). Iron deficiency can also affect cognition and lead to possible neuropsychological impairments (Tapiero *et al.*, 2001:325).

Iron deficiency is the most prevalent nutritional disorder in the world (Youdim, 2000:504). Two thirds of children and women of childbearing age in most developing countries are estimated to suffer from iron deficiency (MacPhail *et al.*, 2004:13). According to an overview compiled by MacPhail (2004:2) on the 29 studies done on anaemia and iron deficiency in South Africa, the prevalence of anaemia in the black female population is 31% and the prevalence of anaemia in the pregnant population is 28%. The prevalence of anaemia in children 6-71 months was 20% and the prevalence of children with depleted iron stores 10% (MacPhail, 2004:2).

