IRON NUTRITIONAL STATUS AMONG FEMALE UNIVERSITI MALAYSIA SABAH (UMS) STUDENTS

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FACULTY OF FOOD SCIENCE AND NUTRITION
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ABSTRACT

IRON NUTRITIONAL STATUS AMONG FEMALE UNIVERSITI MALAYSIA SABAH STUDENTS

The objectives of the present study were to determine iron nutritional status among female Universiti Malaysia Sabah (UMS) students and the differences in dietary iron intake between respondents with and without anaemia. A total of 436 female UMS students of aged 19-26 years were recruited in this study. Iron nutritional status was determined by measuring haemoglobin concentration via gravimetric technique while dietary intake data was obtained through semi-quantitative questionnaire (FFQ) modified from Malaysian Adults Nutrition Survey (MANS) 2003. Anaemia was determined using a single biochemical indicator, which was Hb<12.5g/dL. Prevalence of anaemia was 50.5% in the present study, which was higher than the estimated global prevalence of 30.2%. Most anaemic female students (n=207, 94.1%) were unaware they had Hb<12.5g/dL prior to this study. Malays recorded the highest prevalence of anaemia (53.40%), followed by Kadazans (50.8%) and Chinese (44.5%). The mean dietary iron intake of 14.9±9.3mg corresponded to 74.7% of the recommended nutrient intake. The difference in mean dietary iron intake between anaemic and non-anaemic respondents was not statistically significant (p=0.126). Dietary iron intake was also found to be positively correlated to total energy intake (r_s=0.889, p<0.001). Primary iron sources of dietary iron was malted beverages (25.5% of total reported iron intake), followed by grains or cereal products (20.0%) and meat (18.1%). In conclusion, strategies to improve poor iron nutrition status in female undergraduates need to address promoters and inhibitors of non-haem iron absorption given these main iron intake sources.

ABSTRAK

STATUS ZAT BESI DALAM KALANGAN PELAJAR WANITA UNIVERSITI MALAYSIA SABAH

Objektif-objektif kajian ini adalah untuk mengenalpasti status zat besi dalam kalangan pelajar wanita Universiti Malaysia Sabah (UMS) serta perbezaan pengambilan zat besi antara pelajar anemik dan bukan anemik. Seramai 436 wanita UMS pelajar berumur antara 19 hingga 26 tahun telah terlibat dalam kajian ini. Status zat besi subjek ditentukan melalui pengukuran kepekatan hemoglobin melalui teknik gravimetrik manakala data pengambilan makanan diperoleh melalui borang kekerapan pengambilan makanan semi-kuantitatif (FFQ) yang diubahsuai daripada Malaysian Adults Nutrition Survey (MANS) 2003. Anaemia dikenalpasti melalui satu petunjuk biokimia, iaitu Hb<12.5g/dL. Prevalen anemia dalam kalangan responden adalah 50.5%, jauh lebih tinggi berbanding dengan prevalen global, iaitu 30.2%. Kebanyakkan pelajar wanita (n=207, 94.1%) yang mengalami anaemia tidak sedar bahawa mereka mempunyai Hb<12.5g/dL sebelum kajian ini dijalankan. Responden Melayu mencatatkan prevalen anemia tertinggi (53.4%), diikuti oleh etnik Kadazan (50.8%) dan Cina (44.5%). Min pengambilan zat besi sebanyak 14.9±9.4mg merupakan 74.7% daripada saranan RNI 2005 bagi zat besi. Perbezaan dari segi min pengambilan zat besi antara responden anemik dan bukan anemik didapati tidak signifikan (p=0.126). Walau bagaimanapun, korelasi positif wujud antara pengambilan zat besi dengan jumlah pengambilan tenaga dalam kajian ini (r_s=0,889, p<0.001). Sumber zat besi utama adalah daripada minuman malt (25.5%), diikuti oleh bijirin dan produk bijirin (20.0%) serta daging (18.1%). Kesimpulannya, strategi-strategi untuk memperbaiki status zat besi prasiswazah wanita perlu mengambil kira pengambilan penggalak dan perencat penyerapan zat besi bukan heme memandangkan ia merupakan sumber zat besi utama mereka.

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LIST OF ABBREVIATIONS

BMI	Body mass index
DHS	Demographic and Health Surveys
FFQ	Food frequency questionnaire
Hb	Haemoglobin
Hct	Haematocrit
IDA	Iron deficiency anaemia
MANS	Malaysian Adults Nutrition Survey
MCV	Mean corpuscular volume
MEASURE	Monitoring and evaluation to assess and use results
NCCFN	National Coordinating Committee on Food and Nutrition
RNI	Recommended Nutrient Intake
SF	Serum ferritin
TIBC	Total iron binding capacity
WHO	World Health Organization

LIST OF SYMBOLS

%	Percentage
g	Gram
mg	Milligram
ml	Milliliter
kcal	kilocalorie
n	Number of respondents
<	Less than
≥	Greater or equal to

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Chapter 1

Introduction

1.1 Overview

The Malaysian economy has seen a tremendous growth in recent years as it gears towards high income nation by the year 2020. Similar to other developing countries, Malaysia is now facing the double burden of malnutrition where cases of under-nutrition coexist with increasing prevalence of over-nutrition in its population (Khor and Zalilah, 2003). Several local studies indicated that iron nutritional problem is still a concern among high risk groups including children, adolescents, pregnant women and elderly (Foo *et al.*, 2004; Rosline *et al.*, 2005; Ngui *et al.*, 2011).

Iron nutritional status refers to the equilibrium of iron absorption, storage and utilization in human body. Individual iron status is classified based on the amount of iron store, starting from negative equilibrium and all the way to positive equilibrium of iron store. When presented in ascending order, they are iron deficiency anaemia (IDA), iron deficiency without anaemia, normal iron store and lastly iron overload (WHO, 2001). However, iron status is normally skewed to the negative end of the scale as a result of inadequate dietary iron intake, low bioavailability of iron and frequent blood loss. In fact, iron deficiency anaemia (IDA) is the most common nutritional problem globally, affecting approximately 40% of the world population (WHO, 2011).

Iron is an essential micronutrient required by human body for a battery of metabolic activities and functions. For instance, it is needed for the synthesis of iron-containing enzymes, cytochrome P450 and plays a vital role in electron transport chains as electron carrier (Gibson, 2005). However, most important function of iron is perhaps in the synthesis of haemoglobin for aerobic respiration (Pettit *et al.*, 2011). Compromised iron supply would result in decrease haemoglobin synthesis, thereby leads to the development of microcytic anaemia (Zimmermann and Hurrell, 2007). Dietary iron can be derived in its haem form from animal sources such as meat, fish, poultry and egg. Apart from these, the iron can also be acquired in its non-haem form from plants such as dark green leafy vegetables, legumes and fruits.

Anaemia can be defined as a health condition where insufficient mass erythrocytes are synthesized in the body as a result of low haemoglobin level (WHO, 2011). Across the world, approximately 41.8% of pregnant women and 30.2% of non-pregnant females were suffering from varying degree of anaemia. The statistics was even more staggering in Asia where 68% of non-pregnant women were reported to be anaemic (Badham, 2007). In view of this, the World Health Organization (WHO) pledged to strengthened its commitment in cutting down the prevalence of anaemia in females of reproductive age by half by the year 2025 (Stevens *et al.*, 2013). Interestingly, 50% of the reported anaemia cases were caused by iron deficiency alone, making it a major risk factor for the health condition (WHO, 2008).

Females generally face greater risk for iron deficiency or iron deficiency anaemia (IDA). This is especially so for women age 15-49 years who are classified as females of reproductive age by the World Health Organization (WHO and MEASURE-DHS, 2004). The demand for iron during puberty and pregnancy (Hanafi *et al.*, 2013). On top of that, there is also a need to compensate daily obligatory iron loss of 0.6mg/d as well as menstrual blood loss (Patterson *et al.*, 1998). Menstrual blood loss between 30-40ml per cycle can result in an iron loss between 0.4-0.5mg/day (Gibson, 2005). Other risk factors for iron deficiency in females include parasitic infection, inflammation and the usage of intrauterine birth control devices (Zimmermann and Hurrell, 2007). Haemoglobin concentration below 12g/dl in non-pregnant women and 11mg/dl in pregnant women serve as indicator for anaemia (WHO, 2011a). Anaemia can be further classified based on the degree of severity. The specific cutoffs for each category are listed in Appendix I.

Assessment of iron deficiency anaemia (IDA) at population level is often conducted using haemoglobin level as reference cutoff similar to that of anaemia (WHO, 2011a). Besides, WHO (2007) also recognized the estimation of prevalence of iron deficiency anaemia (IDA) using the prevalence of anaemia as a proxy as it has been known to cause half of the anaemia cases.

Apart from the physiological conditions, individual iron nutritional status is also associated with dietary patterns and habits. Traditionally, vegetarian diet has been linked to greater risk for iron nutritional problem due to its reliance on non-haem iron and high exposure to various iron inhibitors. Achieving the recommended dietary iron intake does not guarantee one from having a healthy iron store as demonstrated by the lack of correlation between dietary iron intake and serum ferritin level (Yen *et al.*, 2008).

Iron deficiency has been demonstrated to affect cognitive functions in young children, immunity, individual endurance level, reproductive health and causes anaemia (Patterson *et. al.*, 1998). Fatigue, shortness of breath and impaired work capacity are some of the early symptoms of the micronutrient deficiency (Gibson, 2005). As the condition progresses, other clinical symptoms including angular stomatitis, dysphagia, hypochlorhydria, spoon nails and anemia may developed. Iron deficiency is also associated with higher risk of maternal and perinatal mortality in both moderate and severe cases of IDA (RNI, 2005). Low birth weight of infant is also common among women with IDA.

Looking from the economic perspective, decrease in cognitive functions and productivity may translate into significant economic loss. Horton and Ross (2002) reported that the annual physical productivity losses due to iron deficiency were approximately $2.32 per capita. This amounted to about 0.57% of a country's gross domestic product (GDP) (Horton and Ross, 2002). A substantial amount of money was spent by authorities worldwide to address the issue of iron deficiency through healthcare system and food supply chain. In United States for instance, $0.10 to $1.00 was spent food fortification per person annually (Badham *et al.*, 2007).

At the other end of the scale, excessive iron intake or iron overload is also part of the iron nutritional problem though its prevalence is lower than iron deficiency. Iron overload or haemochromatosis can arise as a result of excessive iron supplement intake as well as genetic diseases such as mutation at iron receptor HFE-1 (Gibson, 2005). Injection of therapeutic iron and frequent blood transfusion especially in patient with thalassemia are also the risk factors for iron overload. One of the negative impacts of excessive iron intake is the increase risk for cardiovascular disease (Sabate, 2001). Free iron catalyzed Fenton reaction is responsible for the synthesis of oxygen radicals. Free radicals have been known to cause tissue damage and possibly DNA mutation (Kohlstadt, 2013).

1.2 Problem statement

Data on iron nutritional status among females of reproductive age in Malaysia remains limited despite the fact that they are facing higher risk of iron deficiency. Studies conducted in the past indicated that Asian diets generally contain higher amount of iron absorption inhibitors such as phytic acids due to greater consumption of grains and legumes. Thus, Malaysia as an Asian country may also face similar nutritional problem. On top of that, data on the degree of effects of these iron inhibitors in Malaysian food to individual iron nutritional status is also limited.

1.3 Study objectives

Three objectives have been identified and delineated below:

1. To measure iron nutritional status and dietary intake among female students of Universiti Malaysia Sabah.

2. To determine the differences in mean dietary iron intake between students with and without anaemia.

3. To identify major sources of dietary iron among female students of University Malaysia Sabah.

1.4 Study rationale

Iron deficiency anaemia being the most common nutritional problem worldwide has received a wealth of attention from health practitioners across the world (WHO, 2008). However, focus had always been placed on young children, pregnant women and female athletes. At the same time, there is limited information on iron nutritional status of female undergraduate students in Malaysia. Optimum iron nutrition is crucial in students as compromised iron nutritional status causes fatigue and decreased cognitive performance.

The proposed study would assess female university students' iron nutritional status as well determining its relationship with dietary intake pattern. The outcome of the study may provide insights to the prevalence of iron deficiency among young Malaysian females and appropriate measures can be planned to address the issue at the population level.

1.5 Hypothesis

It is hypothesized that dietary iron intake among female students with anaemia is significantly lower than their non-anaemic counterparts and that grains as well as other cereal products are the main sources of dietary iron amongst these students.

The hypothesis was derived from the available literature which indicated higher prevalence of iron deficiency among females of reproductive age due to physiological characteristics and dietary patterns. This is especially in Malaysia where the main sources of dietary iron come from grains and legumes. Absorption of non-haem iron in these food is greatly influenced by the presence of iron inhibitors found abundantly in Asian diet. Subjects with iron deficiency are anticipated to be reflected through lower than normal haemoglobin level among the female subjects (<12g/dl) (WHO, 2011a).

Chapter 2

Literature Review

2.1 Introduction

The indispensable functions of iron in human body had led to extensive studies of the micronutrient in the past. Unlike other nutrients, the body does not possess a specific set of metabolism to excrete excess iron. As a result, iron is carefully regulated via the dietary iron absorption by the epithelial lining of duodenum (Gubler, 1956).

The human body acquires most of the iron (90%) from internal sources such as degradation of worn out erythrocytes every 120 days. Despite so, dietary iron absorption is still being considered of great importance as it compensates obligatory iron loss as well as menstrual blood loss in females of reproductive age. Females of reproductive age are at greater risk for iron nutritional problems due to iron loss induced by obligatory and menstrual blood loss (WHO, 2001).

The absorption of dietary iron is influenced by a several factors related to diet pattern, bioavailability of iron, iron absorption inhibitors and promoters as well as individual health. These factors would be discussed further in this chapter. Particular interests are placed on vegetarian diet and females in reproductive age group in light of the present study objectives. Association of vegetarian diet with higher risk of iron deficiency is often read about and understandable considering the higher dependency on non-haem iron sources as well as greater exposure to iron inhibitors.

2.2 Iron metabolism and bioavailability

2.2.1 Dietary iron absorption metabolism

Iron absorption occurs throughout the entire length of gastrointestinal tract with higher sensitivity at the duodenum region (Brown, 1963). In order to compensate for the lack of iron excretion metabolism, iron absorption is carefully regulated where only 10% of ingested dietary iron is absorbed into the body. It has been theorized that this is part of the protective mechanism against pathogens as increase virulence was observed when free iron atoms are available (Badham, 2007).

Non-haem iron naturally occurs as ferric salts in plants, animals and dairy products. However, trivalent ferric iron in the salts is not readily absorbed by the intestinal mucosa (Gubler, 1956). As a result, the bioavailability of non-haem iron is much lower than haem iron despite accounting for approximately 80% of dietary iron consumed by human. The reduction of ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}) is catalyzed by enzyme ferrireductase (Dcytb) located at the duodenum mucosa (Schmaier and Lazarus, 2011). Acidic condition in the duodenum region greatly favors the reduction process and at the same time inhibiting the dissociation of iron complexes (Gubler, 1956).

Reduced ferrous iron atoms are then transported across the enterocytes via iron transporter known as divalent metal transporter-1 (DMT-1) together with a proton. The bioavailability of non-haem iron can also be interfered by iron absorption inhibitors and individual iron status (Schmaier and Lazarus, 2011). Examples of iron inhibitors include phytate, dietary fibre, polyphenols, calcium and phosphorus.

Unlike non-haem iron, the absorption mechanism of haem iron is yet to be fully established (Anderson *et al.*, 2005). Haem iron derived from animals tissues is absorbed directly into the intestinal mucosa together with protoporphyrin rings attached (Beals, 2013). Degradation of haem moiety within the enterocyte's cytoplasm frees iron atoms from the protoporphyrin rings, allowing them to enter into blood circulation and bind to serum transferrin. Interestingly, haem iron accounts

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