Iron Bioavailability in Thai Diets

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Abstract

Dietary low iron bioavailability intake is an important causation factor of iron deficiency anemia in Asian countries including Thailand. The aim of this study was to estimate the iron bioavailability in the Thai diet by a calculation method that is based on dependent factors, dietary components and physiological iron store. Based on the the latest national nutrition survey of the Thai diet, 1995, the data of nutrient intake per capita per day by region were used for calculating the iron bioavailability at physiological iron store levels; 0, 250, 500 and 1,000 mg of iron. The results showed that the diets consumed by the populations in the Central, North, Northeast and South of Thailand were classified under the calculation method as being of moderate nonheme iron availability. The per cent iron bioavailability values of the Thai diets were within the range 3.7-12.4 per cent of total iron, depending on physiological iron store. The values of all region Thai diets at each iron store level were similar. By the same method, the dietary iron bioavailability of the total Thai diet at any iron store level was markedly lower than the general US diet, which was classified as high nonheme iron availability. When comparison of the iron bioavailability among other different diets was carried out, the values of the total Thai diet were slightly lower than Utah, but higher than US vegetarian and Regional Latin American diets.

Key word : Thai Diet, Iron Bioavailability, Physiological Iron Store

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Iron deficiency anemia is a public health problem in Asian countries, including Thailand[1,2]. One important factor of its causation is low iron bioavailability intake. Knowing the bioavailability of iron in diets consumed by the population is important for assessing the iron nutrition situation in the country. There are 2 main methods for analyzing dietary iron bioavailability, the laboratory and calculation methods. The laboratory method is used for predicting and screening particular food products and food combinations for the bioavailability of iron[3]. For the calculation method, a mathematical model for estimating iron availability in a meal as influenced by iron status, preliminarily proposed by Monsen, is widely accepted[4]. The model was modified for estimating the availability of iron in daily food intake by treating daily dietary intake as one large meal (OLM)[5,6]. Using the average daily dietary intake of a large population, the bioavailability of iron from the population's diet was determined. The objective of this study was to estimate iron bioavailability from the Central, Northern, Northeastern and Southern Thai diets by calculation using the OLM model. The results would be a picture of Thai diet iron bioavailability, compared with those in earlier reports.

MATERIAL AND METHOD

The present study was done by using the data of the latest national nutrition survey of Thailand in 1995[7], which assessed food consumption of the statistically selected 79, 75, 161 and 80 families from the Central (C), Northern (N), Northeastern (NE) and Southern (S) regions of Thailand. The data of nutrient intake per capita per day of the Thai population by regions were used for estimating the iron bioavailability of their diets. Besides, the estimated iron bioavailability of total Thai diets was compared with those of others which were done by the same method, of diets in the US and developing countries. The comparative diets were from three population segments of the general US, a typical diet of residents of a single US state, Utah, and vegetarian as well as from the regional Latin America zone, Brazil and Chile, which were representative of developing countries[6].

The iron bioavailability of Thai diets was calculated by OLM model[6]. Some data of median nutrient intake per capita per day were used to fit, as follows:

Total iron

The total iron intake was calculated in terms of mg/1,000 kcal.

Heme iron

The content of heme iron in Thai diets was calculated from the amount of total iron intake consumed per capita per day multiplied by the proportion of heme iron to total iron content factor in the diet. The heme iron factors for Thai diets reported in the present study were 7 per cent and 5 per cent of total iron for urban and rural diets, respectively, and 6 per cent of total iron on average[8]. The calculated heme iron content was expressed as mg/1,000 kcal.

Nonheme iron

The nonheme iron in Thai diets was estimated from subtracting the heme iron content from the total iron. The content was expressed as mg/1,000 kcal.

Total enhancing unit

One enhancing unit was equal to either 1 mg ascorbic acid or 1 g of animal meat in the diets. The total of enhancing units was the sum of the units from ascorbic and animal meat and expressed as units/1,000 kcal.

Bioavailability of nonheme iron for absorption was classified as low, moderate, or high based on dietary density of enhancing units: low, <50 units/1,000 kcal; moderate, 50-125 units/1,000 kcal; high, >125 units/1,000 kcal. Both heme and nonheme iron bioavailability were varied by physiological iron status, as shown in Table 1. The total iron bioavailable was the sum of heme iron and non heme iron bioavailability in terms of mg/1,000 kcal at each iron store level; 0, 250, 500 and 1,000 mg. The comparative iron bioavailability values of the different diets were presented as per cent bioavailable iron of total iron.

RESULTS

Since the average density of total iron, heme iron, nonheme iron and total enhancing units in the C, N, NE and S Thai diets were quite close to each other, the estimated iron bioavailability of the diets was similar at any iron store (Tables 2, 3). The values of the total Thai diets were 12.4, 8.3,

6.1 and 3.7 per cent of total iron at 0, 250, 500 and 1,000 mg of physiological iron store.

When the total dietary iron of Thai diets was compared with those of the US and diets of the developing countries, the dietary total iron density of the Thai diets was 9.1 mg/1,000 kcal, higher than the US diets, which were 7 mg/1,000 kcal for general US, Utah and vegetarian diets, but similar to the regional Latin American diets, which was 9.0 mg/1,000 kcal. The Thai diet contained nearly half the heme iron density of the general US diet, but slightly lower than the Utah and the Regional Latin American diets. The total of enhancer units of the Thai diet (88.3 units/1,000 kcal) was substantially lower than that of the general US diet (160.1 units/1,000 kcal), and considerably lower than Utah and vegetarian but higher than regional Latin American diets. Based on the studied calculation methods, the diets that were classified into moderate nonheme iron bioavailability were Thai, Utah and vegetarian diets. The general US diet was classified as high nonheme bioavilability, while the regional Latin American diet was classified as low nonheme bioavailability content. Calculation of the dietary iron bioavailability of the Thai diet as influenced by iron status compared with those of others are shown in Fig. 1. The values of the Thai diet at any body iron store levels were lower than the general US diet and Utah but higher than US vegetarian and Regional Latin American diets.

Table 1. Bioavailability of heme iron and nonheme iron as influenced by iron status and dietary composition.

Physiologic iron stores (mg)	Dietary availability of nonheme iron[a]	% Bioavailability	
		Heme iron	Nonheme iron
0	Low	35	5
	Moderate	35	11
	High	35	20
250	Low	28	4
	Moderate	28	7
	High	28	12
500	Low	23	3
	Moderate	23	5
	High	23	8
1,000	Low	15	2
	Moderate	15	3
	High	15	4

[a]Availability of nonheme iron for absorption classified as low, moderate, or high based on dietary density of enhancing units: low,<50 units/1,000 kcal; moderate, 50-125 units/1000kcal; high, >125 units/1,000 kcal. One enhancing unit = 1 mg ascorbic acid = 1 g meat, fish, or poultry.
From : Carpenter and Mahoney,1992(6).

Table 2. Dietary content of heme iron, nonheme iron, enhancers of nonheme iron absorption and classification of dietary nonheme iron availability of Thai diets from different regions.

Dietary data	Central	Northern	North-Eastern	Southern	Total
Total iron (mg/1,000 kcal)	10.6	8.7	8.4	9.5	9.1
Heme iron (mg/1,000 kcal)	0.6	0.5	0.5	0.6	0.5
Nonheme iron (mg/1,000 kcal)	9.9	8.2	7.9	8.9	8.5
Total enhancer (units/1,000 kcal)	91.1	93.6	82.5	97.5	88.3
Animal meat	53.1	45.1	40.1	62.8	46.5
Ascorbic acid	38.0	48.5	42.4	32.7	41.7
Classification of dietary nonheme iron availability	Moderate	Moderate	Moderate	Moderate	Moderate

Table 3. The percentage of iron bioavailability of total iron of the different regions Thai diets.

Physiological iron store	Central	Northern	North-Eastern	Southern	Total
0	12.4	12.4	12.4	12.4	12.4
250	8.3	8.2	8.2	8.2	8.3
500	6.1	6.1	6.1	6.1	6.1
1,000	3.7	3.7	3.7	3.9	3.7

Table 4. Dietary content of heme iron, nonheme iron, enhancers of nonheme iron absorption and classification of dietary nonheme iron availability from the Thai diet, and others.

Dietary data	Thai diets	US diets[a]			Regional[a] Latin American
		General US	Utah	Vegetarian	
Total iron (mg/1,000 kcal)	9.1	7.0	7.0	7.0	9.0
Heme iron (mg/1,000 kcal)	0.5	1.1	0.6	-	0.6
Nonheme iron (mg/1,000 kcal)	8.5	5.9	6.4	7.0	8.4
Total enhancer (units/1,000 kcal)	88.3	160.0	110.0	90.0	34.0
Animal meat	46.5	111.0	50.0	-	24.0
Ascorbic acid	41.7	50.0	60.0	90.0	10.0
Classification of dietary nonheme iron availability	Moderate	High	Moderate	Moderate	Low

[a] From Carpenter and Mahoney, 1992(6)

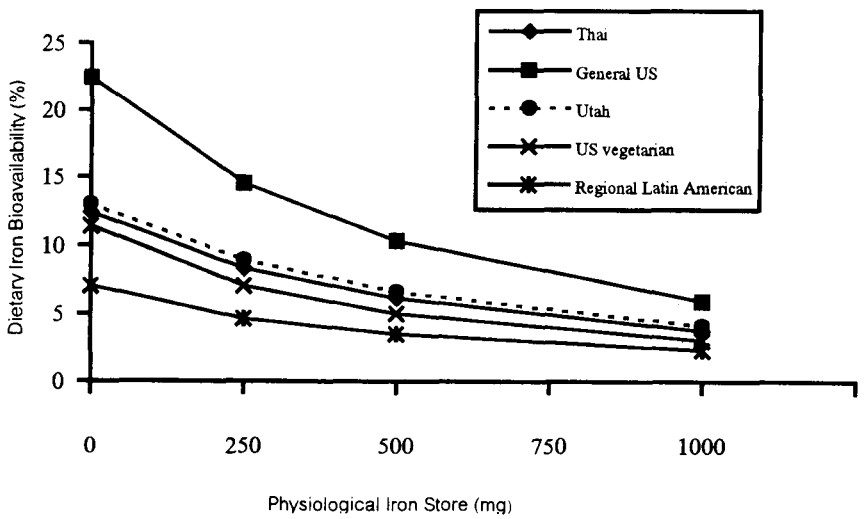

Fig. 1. Dietary iron bioavailability of the Thai diet compared with the others at any physiological iron store.

DISCUSSION

It is clear that the dietary components influence nonheme iron absorption. Ascorbic acid and animal meat are enhancing factors while phytate and tannins are inhibiting factors of iron absorption. Since data of dietary phytate and tannins content were not commonly available, only the content of dietary ascorbic acid and animal meat were employed as criteria for nonheme availability classification in the calculation method of iron bioavailability. Besides dietary components, both heme and nonheme iron absorption is markedly dependent on body iron store. In the same diet, a person with a low body iron store would absorb more iron than another with a high iron store. The calculation method of iron bioavailability as influenced by iron store was, therefore, used in the present study.

Although the food consumption habits of Thais living in the C, N, NE and S of Thailand are different, the median intake of iron, heme iron, nonheme iron and vitamin C in terms of mg/1,000 kcal were in a close range. Based on the total enhancing unit component, the nonheme iron availability of all Thai diets was classified into moderate level. The calculated iron bioavailability of 4 regions were similar at any iron store; those were 12.4, 8.3, 6.1 and 3.7 per cent of total iron at iron store of 0, 250, 500 and 1,000 mg of iron, respectively.

As the present study results demonstrate, total iron density in the Thai diet was considerably higher than in general US diets. One of the reasons was the high amount of iron consumed from staple foods. Thais consume a rice-staple diet. Approximately 140.3 g of white rice and 140.8 g of glutinous rice are taken daily[7]. White and glutinous rice contain 0.7-1.1 and 1.6-2.5 mg/100 g of iron respectively[9]. This reasonable finding was consistent with the high iron density in the Regional Latin American diets, in which rice is currently becoming a staple food for 70 per cent of the population, especially in urban areas[10]. Because of the low protein pattern of the Thai diet, a lower heme iron density in the diet was found when compared with the general US diet. Although the amount of animal meat consumed among Thais was higher than the regional Latin American population, their heme iron densities were lower. This finding was possibly due to the lower heme content in Thai animal meat. The ascorbic acid content in the vegetarian diet was high, because plant foods are good sources of ascorbic acid. Regarding total enhancer units, the content in the general US diet was the highest because of the high levels of animal meat, leading it to be classified under the study's calculation method as high nonheme iron availability. The Thai diet was classified into moderate nonheme iron availability and so were the Utah and vegetarian diets, while the regional Latin American diet was low nonheme iron availability. The calculated iron bioavailability in the Thai diet, as shown upon the curve line plotted against iron store, was lower than the general US diet and Utah diets but higher than the vegetarian and regional Latin American diets. This curve line is useful for estimating the bioavailability of iron from the diet consumed under conditions of known body iron store of an individual or a population, which could be determined by Cook's method[11]. However, the user should realize that the iron bioavailability from the curve might be overestimated, because the inhibitor factor of available iron was not included in the calculation method.

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ปริมาณเหล็กที่ใช้ประโยชน์ได้ในอาหารบริโภคไทย

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การได้รับอาหารที่มีเหล็กที่ร่างกายใช้ประโยชน์ได้ต่ำ เป็นสาเหตุสำคัญของการเกิดภาวะโลหิตจางจากการขาดเหล็กในประเทศเอเชียรวมทั้งประเทศไทย วัตถุประสงค์ของการศึกษานี้จะประมาณค่าเหล็กที่ใช้ประโยชน์ได้ในอาหารไทยโดยวิธีคำนวณซึ่งขึ้นอยู่กับปัจจัยที่เกี่ยวข้องคือ ส่วนประกอบในอาหารและภาวะเหล็กในร่างกาย จากข้อมูลการสำรวจอาหารบริโภคของไทยครั้งล่าสุดในปี พ.ศ. 2538 ปริมาณเหล็กรวมและส่วนประกอบในอาหารที่มีผลต่อการดูดซึมเหล็กได้นำมาใช้ในการคำนวณปริมาณเหล็กที่ใช้ประโยชน์ได้ของร่างกายที่มีภาวะเหล็กในปริมาณ 0, 250, 500 และ 1,000 มก. ผลการศึกษาพบว่าอาหารไทยภาคกลาง, เหนือ, ตะวันออกเฉียงเหนือและใต้มีเหล็กไม่ใช้ฮีมที่ใช้ประโยชน์ได้อยู่ในระดับปานกลาง มีค่าร้อยละของเหล็กที่ใช้ได้ต่อเหล็กรวมอยู่ในช่วง 3.7-12.4 ขึ้นอยู่กับภาวะเหล็กในร่างกาย ที่ภาวะเหล็กระดับหนึ่ง ๆ อาหารไทยทุกภาคจะมีปริมาณค่าเหล็กที่ใช้ประโยชน์ได้เท่ากัน โดยวิธีการศึกษาแบบเดียวกัน ค่าปริมาณเหล็กที่ใช้ประโยชน์ได้ในอาหารไทยที่ทุกระดับของภาวะเหล็กในร่างกาย จะต่ำกว่าของอาหารอเมริกันทั่วไปซึ่งเป็นอาหารที่มีเหล็กรูปไม่ใช่ฮีมที่นำไปใช้ได้อยู่ในระดับสูง เมื่อเปรียบเทียบกับค่าของเหล็กที่ใช้ประโยชน์ได้ในอาหารอื่น พบว่าค่าของอาหารไทยมีค่าต่ำกว่าอาหารของยูกาห์เล็กน้อยแต่สูงกว่าอาหารมังสวิรัติของชาวอเมริกันและแถบลาตินเมริกัน

คำสำคัญ : อาหารบริโภคไทย, เหล็กที่ใช้ประโยชน์ได้, ภาวะเหล็กในร่างกาย

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