Research Article

Assessment of Dietary Bio-Accessible Iron from Reference Meals of Hostel Diets

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Abstract

Iron deficiency is the most prevalent micronutrient deficiency affecting 30% of the population in the world. The aim of this study was to evaluate hostel meals for total iron, dialyzable iron and *in vitro* iron bio- accessibility as hostel meals represents the diets of general population. The percent *in vitro* iron bioavailability ranged from 2.00-22.60 in breakfast, 1.83-2.94 in lunch and 1.93-3.62% in dinner. The maximum bio-accessibility of iron from hostel meals was from breakfast (5.61%) then followed by dinner (2.34%), and lunch (2.27%). *In vitro* iron bio-accessibility of hostel meals was found maximum in Sunday breakfast (22.6%) followed by Tuesday breakfast in which *paneer bhurji* and *parantha* was served. The average *in vitro* availability for various cereals, legume milk and vegetable preparations varied between 2.10 to 5.16, 3.29 to 8.15, 3.16 to 19.41 and 8.15 to 15.90%, respectively. The meal analysis showed that iron bio-accessibility of different meals ranged between 2.27 to 5.61 % indicating low bio-accessibility of iron in their diets. There was a wide variation in the total as well as bio-accessible iron in different foods and meals of weekly menu suggesting a dire need to proper plan the meals so that foods with maximum total as well as bio-accessible iron can be included in order to balance their meals to provide adequate iron thus preventing iron deficiency.

Keywords: Total iron, dialyzable iron, hostel, iron bio-accessibility

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Introduction

Iron Deficiency Anemia (IDA) is a global problem affecting nearly 1.78 billion people of which 358 million are from developing world as reported by World Health Organization [1]. National and regional surveys indicate that the prevalence of IDA could be affecting more than one billion people, mostly women of child bearing age and young children [2]. Iron Deficiency Anemia (IDA) alone contributes to over 100,000 maternal and almost 600,000 perinatal deaths. The IDA has a massive economic cost adding to the burden on the health system affecting cognitive performance of children and productivity of adults [3].

Iron deficiency is defined as decreased total body iron content and it occurs when iron deficiency is severe enough to diminish erythropoiesis and cause of anemia. The main reasons for IDA have been determined to be inadequate intake of iron, low bioavailability (1-6%) of dietary iron from plant foods due to inhibitory factors, low levels of absorption enhancers in the diet, repeated pregnancies, increased needs during growth and development among children and adolescents, parasitic infestations and chronic blood loss. However, anemia is wide spread in India in spite of diversity in food habits, particularly in the consumption of cereal based diet.

Determination of bioavailability of dietary iron is extremely important in evaluating cause of iron deficiency anemia. “Bio-accessibility” is defined as the portion of ingested iron that is available for use in metabolic process or deposition in storage compounds and is the key concept in iron nutrition [4]. An *in vitro* method that stimulates human digestion and absorption of dietary iron from complex meals has been described by Miller *et al* [5]. Both enhancing and inhibiting factors of iron absorption have been shown to respond *in vitro* in the same way as they affect iron absorption *in vivo*. Non heme iron is poorly absorbed compared to heme iron and many nutritional factors are known to influence its absorption. The absorption of iron from the diet is a major determinant of the iron status of an individual.

In most of the countries like India vegetarian diets are mainly plant based. Hostel diets covering majority of the food groups except meat and fish represents the diets of general population. Menu analysis has been used to assess the iron available to hostel residents. Today solving of this micronutrient malnutrition ‘anaemia’ is an important goal in order to improve iron status by giving a right direction to their meal pattern. The understanding of bio accessible iron from individual foods as well as meal composites will help to draw dietary guidelines for the prevention of anemia. So in this study, the dietary bio-accessible iron from reference meal of hostel diets was assessed.

Materials and Methods

The study was carried out in the girls' hostels of Punjab Agricultural University, Ludhiana. Information regarding weekly set menu was collected from the hostel mess. The individual food samples from three meals i.e. breakfast, lunch and dinner were collected from the hostel mess for seven consecutive days. The composite meals comprising of individual foods consumed were also collected from the hostel residents. The collected samples were brought to the laboratory of Department of Food and Nutrition, Punjab Agricultural University, Ludhiana. Each meal of the subject was homogenized using stainless steel blades. A portion of homogenized sample of each meal was kept in hot air oven at 60^{o}C till constant weight to determine the moisture content in fresh samples. Total iron was estimated in dried samples whereas dialyzable iron was determined in fresh samples.

Total iron was estimated by Atomic Absorption Spectrophotometer after wet digestion. *In vitro* iron bioaccessibility was assessed by the method given by Miller *et al* [5]. The samples were digested *in vitro* and the proportion of iron which was diffused across semi permeable dialyzable membrane was used as an index of iron bioavailability. All the parameters were calculated per mg of iron present in each meal sample. An *in vitro* method for estimating food iron involves simulated gastrointestinal digestion followed by measurement of soluble, low molecular weight iron. Individual food samples and meals were homogenized and exposed to pepsin at pH 2. Dialysis was used to adjust the pH to intestinal levels and digestion was continued after the addition of pancreatin and bile salts. Iron from the digestion mixture which diffused across a 6000 to 8000 molecular weight cutoff semi-permeable dialyzable membrane was used as an indicator of available iron. Iron present in the dialysate at the end of simulated gastrointestinal digestion represented the dialyzable iron fraction. Dialysates were mixed with 5 ml of nitric acid and analyzed the dialyzable iron content at Atomic Absorption Spectrophotometer.

Bio-accessible iron was calculated as: *In vitro* iron bio-accessibility (%) = Dialyzable iron/ Total iron x 100.

Mean and standard deviation for various parameters were computed. Analysis of variance was employed to assess the difference in meal combinations and Critical Difference (C.D.) was calculated using Microsoft excel (2007) statistical analysis tool pack.

Table1 Weekly menu of the selected hostel mess

Day	Breakfast	Lunch	Dinner
Sunday	*Dal parantha*, bread, butter/jam, milk/tea	Rice, *chapati*, white *channe* , curd/*raita* salad(onion, carrot, chilli)	*Chapati* , rice, *dal (mah+ Rajmah), halwa*, salad (onion, chilli)
Monday	Potato p*arantha*, butter/curd, milk/tea, bread, butter/jam	Rice, *chapati* , white *channe* , curd/*raita*, salad(onion, carrot, chilli	*Chapati* , *mah channe ki dal*, mix vegetable (*carrot peas potato* mix), *Kheer*, salad(onion, chilli)
Tuesday	Plain *parantha*, *paneer bhurji*, bread, butter/jam, milk/tea	Rice, *chapati* , Rajmah, curd, salad (onion, chilli)	*Chapati*, *dal (moong-masoor*), *cauliflower potato* vegetable, custard, salad (onion, chilli)
Wednesday	Cauliflower *parantha* , bread, butter/jam, milk/tea	Rice, *chapati* , *pakoda kadhi*, *nutri nuggets potato veg* , curd/*raita*, salad (onion, carrot, chilli)	*Chapati* , *dal (moong sabut*), chilli paneer, *Gulab jamun*, salad (onion, chilli)
Thursday	*Methi parantha*, bread, butter/jam, milk/tea	Rice, *chapati* , *kale channe*, curd/*raita* salad(onion, carrot, chilli)	*Chapati* , masoor *dal*, *carrot cauliflower potato* mixed vegetable, *seviyan* , salad (onion, chilli)
Friday	Plain *parantha*, *kale channe*, bread, butter/jam, milk/tea	Rice, *tandoor chapati* , *dal makhni*, curd/*raita* salad(onion, carrot, chilli)	*Chapati* , *channa dal* ,*potato veg, jalebi*, salad (onion, chilli)
Saturday	Bread, *tikki / omelette* , milk/tea	Rice, *chapati* , *green peas potato mix* veg, curd/*raita* salad(onion, carrot, chilli)	*Chapati* , *dal (dhuli masoor), cabbage veg*, banana, salad (onion, chilli)

Results and Discussion

Meal pattern

The subjects followed a weekly set menu pattern as they were residing in the hostel and had food in the hostel mess (**Table 1**). All the subjects used to take three main meals as breakfast, lunch and dinner. Some of the subjects used to take milk or tea at the bed time. The breakfast of the hostel mess comprised mainly *parantha*, bread with curd or

butter, milk or tea was consumed along with the breakfast. Lunch of the hostel was mainly comprised of *chapati*, rice, vegetable, curd/ *raita/ kadhi*, salad (onion, carrot, chilly). The dinner included *chapati*, *dal*, vegetable, any sweet dish (*kheer*, custard, *gulab jamun*, *seviyan*, banana, *jalebi*, and *halwa*) and salad as onion and chilli. They were served rice once in a week in a dinner. Snacks items as *pakoda*, *patties*, sandwich and tea was taken by only some girls as these were not included in the hostel menu. These items could be taken by paying extra amounts by the hostellers. They were taking milk or tea at the bed time as optional. The description of these recipes is given in **Table 2**.

Table 2 Description of Punjabi recipes consumed by the subjects

Recipe	Description
Cereals	
Chapati	Wheat flour dough, rolled and baked on griddle.
Tandoor *chapati*	Wheat flour dough, rolled and baked in tandoor.
Plain p*arantha*	Wheat flour dough, rolled and shallow fried.
Dal parantha	Wheat flour dough prepared by using dehusked legume, rolled and shallow fried.
Methi parantha	Wheat flour dough prepared by using fenugreek leaves, rolled and shallow fried.
Potato p*arantha*	Wheat flour dough, stuffed with potato, rolled and shallow fried
Gobi parantha	Wheat flour dough stuffed with cauliflower, rolled and shallow fried.
Poori	Wheat flour dough, rolled and deep fried.
Pulses and legumes	
White *channe with aaloo*	Chickpea preparation with potatoes in curry form
Kale channe curry	Bengal gram preparation in curry form
Nutri *aaloo*	A curry preparation using Soybean nuggets and potatoes
Rajmah	Kidney bean preparation in curry form
Saboot masoor	Whole lentils curry preparation
Dal makhani	Black gram curry preparation with added cream
Saboot moong	Whole green gram curry preparation
Chana dal	Dehusked Bengal gram curry preparation
Mah+chane ki dal	Black gram and dehusked Bengal gram preparation
Moong+masoor ki dal	Dehusked green gram and lentil curry preparation
Mah ki dal	Dehusked mash bean preparation
Dhuli moong ki dal	Dehusked green gram preparation
Kadhi	A preparation from Bengal gram flour and curd
Dry *kale channe*	Bengal gram preparation in dry form
Milk and milk products	
Kheer	Rice cooked with milk and sugar
Seviyan	Vermicelli cooked in milk with sugar
Chilli paneer	Cottage cheese with capsicum preparation
Paneer *bhurji*	Cottage cheese scrambled
Vegetables	
Gajar matar aaloo mix veg	Mixed vegetable preparation using carrots, peas and potatoes
Cabbage vegetable	Cabbage vegetable preparation
Gobi aaloo	Mixed vegetable preparation using cauliflower and potatoes
Green *matar Aaloo bhaji*	Green pea and potato curry preparation
Gobi Gajar aaloo bhaji	Mixed vegetable preparation using cauliflower, carrots and potatoes
Aaloo(Potato) *tikki*	Boiled potato mixed with vegetables and deep fried
Aaloo bhaji	Potato vegetable preparation
Others	
Gulab jamun	Concentrated milk with refined flour, fried and dipped in sugar syrup
Halwa	Semolina, roasted with fat and cooked in water with sugar
Jalebi	Refined flour, fermented, fried and dipped in sugar syrup

Total iron content, dialyzable iron, and in vitro iron bioaccessibility from the hostel meals

The total iron content, dialyzable iron, and *in vitro* iron bioaccessibility from the hostel meals has been given in **Table 3**.

The average iron content in breakfast of hostel mess ranged from 2.17 to 4.91 mg, 2.72 to 5.13 mg in lunch and 2.54 to 4.91 mg/100g in dinner. The average iron content in breakfast, lunch, dinner was 3.59, 3.91 and 3.90

mg/100g, respectively. The average total iron content was maximum in lunch, followed by the dinner and breakfast. The total iron intake by the subjects from all the meal was 11.4 mg/day. Intake of iron in India was less than 50% of the recommended dietary allowances and iron density was about 8.5 mg/1000 kcal [6]. The average intake of iron in breakfast, lunch and dinner was 2.31, 2.66 and 3.10mg, respectively by the farm women [7].

Table 3 Total iron, dialyzable iron, and *in vitro* iron bioavailability from the hostel meals (per 100 g of meal)

Parameter	Meal			P value	CD at 5% level	Total
	Breakfast	Lunch	Dinner			
Total iron , mg						
Range	2.17-4.91	2.72-5.13	2.54-4.91			
Mean±SD	3.59±0.43	3.91±0.174	3.90±0.38	NS	-	11.4±5.14
Dialyzable iron ,mg						
Range	0.072-1.11	0.078-0.094	0.072-0.102			
Mean±SD	0.24±0.4	0.09±0.01	0.09±0.01	NS	-	0.42±0.34
***In vitro* iron bioavailability, %**						
Range	2.00-22.60	1.83-2.94	1.93-3.62			
Mean±SD	5.61±2.78	2.27±0.39	2.34±0.57	NS	-	3.41±1.23*

* Mean value of breakfast, lunch and dinner
NS: No significant difference observed between the meals

The average dialyzable iron from hostel meals namely breakfast, lunch and dinner was 0.24, 0.09 and 0.09 mg with the range of 0.072-1.11, 0.078-0.094 and 0.072 to 0.102 mg/100g, respectively. The average dialyzable iron was maximum in breakfast (0.24 mg) followed by lunch and dinner. The total dialyzable iron from three meals was 0.42 mg from the hostel diet. Total dialyzable iron intake from three meals was reported as 0.63mg by the farm women [7].

The percent *in vitro* iron bio-accessibility ranged from 2.00-22.60 in breakfast, 1.83-2.94 in lunch and 1.93-3.62mg in dinner with the mean values of 5.61, 2.27, and 2.34%, respectively. The maximum bioavailability of iron from hostel meals was from breakfast (5.61%) then followed by dinner (2.34%), and lunch (2.27%). Inadequate dietary iron and poor bioavailability of dietary iron from the fiber, phytates rich Indian diets were the major factors responsible for high prevalence of anemia [8]. Another study reported that the maximum bioavailability of iron from meals collected from adult women of farm families was in dinner followed by breakfast and lunch [7].

Total iron, dialyzable iron, and in vitro iron bioavailability of analyzed hostel meals from set menu of seven days

Total iron, dialyzable iron, and *in vitro* iron bioavailability of analyzed hostel meals from set menu of seven days has been presented in **Table 4**. Hostel menu was analyzed for total iron and it was found that total iron content was maximum in the Sunday breakfast (4.91 mg/100g) in which *dal parantha* was main in the menu followed by Friday breakfast in which plain p*arantha* with *kale channe* was served. In lunch, Sunday lunch was having maximum iron content (5.13 mg/100g) where rice, *chapati* and white *channe* was there in the menu followed by Friday lunch (4.4 mg/100g). In dinner, maximum iron content was on the Saturday (4.91 mg/100g) where *chapati*, *dal* (*dhuli masoor*), cabbage vegetable and banana were served.

Table 4 Total Iron, dialyzable iron, and *in vitro* iron bio-accessibility of analyzed hostel meals from set menu of seven days (per 100g meal)

Day	Breakfast			Lunch			Dinner		
	Total iron, mg	Dialyzable iron, mg	Bioaccessibility %	Total iron mg	Dialyzable iron, mg	Bioaccessibility %	Total iron mg	Dialyzable iron, mg	Bioaccessibility %
1	2.87±0.33	0.078±0.61	2.72	3.06±0.41	0.078±0.37	2.55	2.54±0.18	0.092±0.16	3.62
2	2.17±0.36	0.092±0.13	4.24	2.72±0.19	0.080±0.16	2.94	3.56±0.78	0.080±0.24	2.25
3	3.31±0.3	0.079±0.32	2.39	3.32±0.24	0.079±0.36	2.38	3.25±0.3	0.072±0.09	2.22
4	3.60±0.48	0.072±0.25	2.00	4.70±0.02	0.090±0.14	1.91	4.20±0.36	0.093±0.09	2.21
5	4.30±0.37	0.136±0.34	3.16	4.40±0.03	0.088±0.38	2.00	4.30±0.21	0.088±0.14	2.05
6	4.01±0.01	0.088±0.07	2.19	4.07±0.08	0.092±0.13	2.26	4.91±0.13	0.102±0.70	2.08
7	4.91±0.21	1.110±0.09	22.60	5.13±0.25	0.094±0.23	1.83	4.60±0.7	0.089±0.40	1.93

Values were Mean±SD
1-Monday, 2-Tuesday, 3-Wednesday, 4-Thursday, 5- Friday, 6-Saturday, 7-Sunday

Dialyzable iron was found maximum in Sunday breakfast (1.110 mg/100g), in this *dal* p*arantha*, bread, butter and milk was there. In lunch it was maximum in Sunday lunch (0.094 mg/100g). Dialyzable iron was maximum in

Saturday dinner (0.102 mg/100g) in which *chapati*, *dal* (*dhuli masoor*), cabbage vegetable, banana was there in the main menu followed by thursday dinner (0.093 mg/100g) where *chapati*, *dal* (masoor), *Gajar Gobi aaloo* mix vegetable and *seviyan* was served.

Table 5 Total iron, dialyzable iron, and *in vitro* iron bio-accessibility of analyzed individual foods from hostel mess

Food	Total iron, mg/100g	Dialyzable iron, mg/100g	*In vitro* iron Bioaccessibility %
Cereals			
Chapati	6.24±0.69	0.179	2.87
Tandoor *chapatti*	7.27±0.01	0.181	2.49
Plain *parantha*	5.06±0.76	0.173	3.42
Dal parantha	6.01±1.49	0.189	3.14
Methi parantha	6.91±0.88	0.188	2.72
Aaloo parantha	8.54±0.92	0.259	3.03
Gobhi parantha	4.34±0.33	0.224	5.16
Poori	7.32±0.27	0.154	2.10
Bread	6.60±0.01	0.143	2.17
Rice	6.66±1.50	0.206	3.09
Pulses and legumes			
White *channe with* potato	7.34±1.88	0.4	5.45
Kale *channe* (Bengal gram)curry	5.67±1.29	0.462	8.15
Nutri *aaloo*	8.02±0.89	0.5	6.23
Rajmah	7.61±0.07	0.423	5.56
Saboot masoor	7.13±0.93	0.364	5.11
Dal makhani	6.72±1.32	0.32	4.76
Saboot moong	6.59±0.25	0.4	6.07
Chana dal	6.90±0.78	0.318	4.61
Mah+chane ki dal	8.48±0.66	0.28	3.30
Moong+masoor ki dal	6.73±0.22	0.364	5.41
Mah ki dal	7.59±0.18	0.32	4.22
Dhuli moong ki dal	7.47±0.93	0.318	4.26
Kadhi	5.40±1.27	0.263	4.87
Dry *kale channe*	5.20±0.57	0.171	3.29
Milk and milk products			
Custard	6.44±0.42	1.25	19.41
Kheer	6.88±0.16	0.393	5.71
Seviyan	5.69±1.75	0.44	7.73
Chilly *paneer*	7.37±0.07	0.233	3.16
Paneer bhurji	5.07±0.47	0.325	6.41
Vegetables			
Gajar matar aaloo mix veg	6.46±0.78	0.889	13.76
Cabbage vegetable	6.29±0.94	1	15.90
Gobi aaloo	6.04±2.21	0.737	12.20
Green *matar aaloo bhaji*	5.97±0.72	0.611	10.23
Gobi gajar aaloo bhaji	6.75±0.64	0.55	8.15
Aaloo patties	6.68±1.73	0.361	5.40
Aaloo bhaji	5.67±1.10	0.611	10.78
Others			
Gulab jamun	6.01±0.93	0.25	4.16
Halwa	5.72±0.56	0.578	10.10
Jalebi	6.03±1.22	0.257	4.26
Omlette	8.2±0.22	0.284	3.46

Values were Mean ±SD

In vitro iron bio-accessibility was maximum in Sunday breakfast (22,6%) followed by Tuesday breakfast in which *paneer bhurji* and *parantha* was served. In lunch, Tuesday lunch was having maximum (2.94%) where rice,

chapati, rajmah , curd/*raita*, was there in the menu followed by Monday lunch (2.59%). In dinner, maximum i*n vitro* iron bio-accessibility was on the Monday (3.62%) where *chapati, dal* (*mah chana dal*), mix vegetable, *kheer* was served. Phytates, oxalates and polyphenols are the examples of inhibitors that can impair iron absorption, whereas organic acids such as ascorbic acid and citric acid may have a favourable effect on the iron absorption [9]

Total iron, dialyzable iron, and in vitro iron bio accessibility of individual foods from the hostel meals

The total iron content, dialyzable iron, and *in vitro* iron bio-accessibility of individual foods from the hostel meals has been given in **Table 5**.

Individual foods from hostel menu was analyzed for total iron and it was found that among foods of cereal group, total iron content was maximum in the potato *parantha* (8.54 mg/100g) followed by *poori* (7.32mg/100g) and minimum in cauliflower *parantha* (4.34 mg/100g). The dialyzable iron was maximum in potato parantha (0.259mg/100g) followed by cauliflower parantha (0.224mg/100g) and minimum in bread (0.143mg/100g). *In vitro* iron bioaccessibilty was found to be highest in cauliflower parantha (5.16%) and lowest in poori (2.10%).

Among legumes, total iron ranged from 5.20 to 8.48mg/100g with maximum and minimum values in whole mash with dehusked Bengal gram and dry Bengal gram, respectively. Total iron in dehusked mungbean with dehusked lentil, dehusked Bengal gram, kidney bean, chickpea, and whole mungbean was reported as 5.60, 6.10, 6.33, 4.97 and 7.34mg/100g dry matter, respectively [10]. The maximum dialyzable iron was found in Soya nuggets and Bengal gram as 0.50 and 0.462mg/100g followed by Rajmah (0.423mg/100g). The average *in vitro* availability for various legume preparations in the study varied between 3.29 to 8.15%. Based on the classification of FAO/WHO [11], the iron bioavailability of various legume preparations was found to be intermediate as it is ranged between 5 to 10%. Kaur [12] reported the synergistic effect of onion, tomato and garlic at different levels i.e. 25 to 100g for onion and tomato and 5 to 20g for garlic was well pronounced as the percent increase of *in vitro* bio accessibility by 11.9 to 54.6%.

Among milk and milk products, maximum iron content was in chilli paneer (7.37mg) followed by *kheer* (6.88mg) and custard (6.44mg/100g). The dialyzable iron was maximum in *seviyan* (0.440mg/100g) followed by *kheer* (0.393mg/100g) and *paneer bhurji* (0.325mg/100g). Among these products, custard had highest bio-accessibility of iron followed by *seviyan* and *paneer bhurji* i.e. 19.41, 7.73 1nd 6.41%, respectively.

Among different vegetable preparations, the total iron content was maximum in mixed vegetable (cauliflower, carrot and potato mix) followed by carrot peas potato vegetable and cabbage vegetable. The *in vitro* iron accessibility among all vegetables was maximum in cabbage vegetable (15.9%) followed by carrot peas potato vegetable (13.76%) and cauliflower potato (12.20%).

In other products, omlette had the highest iron content (8.20mg/100g) followed by *jalebi* (6.03mg/100g) and *gulab jamun* (6.01mg/100g) where as, dialyzable iron was maximum in *halwa* (0.578mg/100g) and omlette (0.284mg/100g). Iron bio-accessibilty was maximum in *halwa* (10.10%) followed by *jalebi* (4,26%) and *gulab jamun* (4.16%).

The results revealed that though no difference was observed in total iron content of cereals and legumes but there was difference in dialyzable iron content. This might be due to promoters and inhibitors present in cereals and legumes that influence the dialyzable iron content which represents the iron available to the human body. Many studies have reported that use of onion and tomatoes in legume preparations significantly increased the iron bio-accessibility. Citric and malic acid are organic acids that contribute taste of tomato fruit have been reported to enhance iron bio-accessibility in legumes [13]. The *in vitro* experiments showed a much greater solubilization of iron from potato than from the other foods examined. There was a correlation between iron solubilization and ascorbic acid content of potatoes (r= 0.76). It appears that potatoes contain iron of moderate availability, possibly higher than most vegetables. They also provide ascorbic acid which may enhance iron absorption from a meal if present in sufficient quantities [14].

Conclusion

The study concluded that iron bio-accessibility of different meals ranged between 2.27 to 5.61 % indicating low bio-accessibility of iron in their diets. Variation in the iron bio-accessibility of different meals was due to the variation in composition of meals which affects the iron absorption. The meals in this study were cereal based and not identical. Differences in the iron bio-accessibility between individual food and in single meal could be caused by presence of enhancers and inhibitors among meals. There was a wide variation in the total as well as bio-accessible iron in different foods and meals of weekly menu suggesting a dire need to plan the meals so that foods with maximum total as well as bio-accessible iron can be included in order to balance their meals to provide adequate iron thus preventing iron deficiency.

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