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ISOTOPE AIDED STUDIES OF THE BIOAVAILABILITY OF IRON FROM HUMAN DIETS CONSUMED IN PERU

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Abstract

Iron deficiency anaemia is an important health problem in Peru, which affects approximately 25 % of the population. The most vulnerable groups are children below 5 years of age and pregnant women, of whom 64% and 53% respectively are anemic. The main reason for this deficiency is inadequate iron intake. Heme iron consumption is very low, and non-heme iron is virtually the only source of iron in the diet. Despite regional differences in food consumption, wheat, salt and sugar are widely consumed in all areas. Wheat is likely to be the most suitable food vehicle for iron fortification due to the processing required. Based on the recent food consumption surveys conducted in Lima by the IIN, we selected examples of typical main meals and measured iron bioavailability in the diet using an extrinsic tag method with 1.5 μCi of ^{59}Fe and 5 μCi of ^{55}Fe as markers. Coffee with bread and butter for breakfast, noodle soup with vegetables, rice with seasoned tripe (cow), bread and lemonade for lunch; and noodle soup with vegetables and bread for dinner were used to measure iron absorption. Thirteen adults in apparent good health, 5 male and 8 female, with normal hemoglobin levels participated in the study. The mean iron absorption from breakfast was 4.2% ± 4.1; from lunch 14.65% ± 10.95, and from dinner 5.1% ± 2.84. The presence of heme iron from tripe and ascorbic acid from lemonade improved iron absorption.

1. SCIENTIFIC BACKGROUND AND SCOPE OF THE PROJECT

Iron deficiency anemia is the most common single nutrient deficiency in the world [1-5]. Its prevalence is worldwide, although the most affected are the developing countries [2-3]

Pregnant women and small children are the high risk groups to develop iron deficiency anemia due to their higher iron requirements [1-3]. Iron-deficiency alters cellular immunity and may produce an increase in morbidity due to infectious diseases [5]. It also produces a decrease in work capacity [6-8]. In children, iron deficiency affects learning capacity and results in changes in behavior [9-11]. In pregnancy, there is information that suggests that severe anemia increases the risk of maternal morbidity and mortality as well as premature delivery [3]. The control of iron deficiency has considerable potential in the improvement of maternal and child health.

In Peru there is no programme for combating iron deficiency. Considering the importance of this nutrient in the health status of the mother and child, we were motivated to develop a programme of iron fortification as a strategy for combating anaemia. As an essential first step in this strategy, we carried out a representative population based survey in the city of Lima (30% of the national population) to measure the prevalence of iron deficiency anaemia in these risk groups. The International Atomic Energy Agency supported part of this survey last year, preliminary results were presented during the First Research Co-ordination Meeting.

Information on socio-economical indicators, pre-natal control and anthropometry were recorded. Presently we are analysing the correlation of these variables with the level of anaemia.

We have recently obtained a grant from the Panamerican Health Organization (PAHO) which will complement the above mentioned studies and allow us to measure the extent to which iron deficiency explains the high rates of anemia that have been observed among pregnant women in Lima (53%) and to assess the prevalence of other micro-nutrient deficiencies in this representative sample of pregnant women from Lima, Peru. We have partially analysed these samples (ferritin and folic acid). Results will be presented later.

In addition we obtained information on food consumption, for the selection of an appropriate food vehicle and the selection of the main meals consumed by most of the population in the city of Lima. Some examples of these diets were used to measure iron bioavailability. This information also had been useful for the demonstration of the severity of this nutritional deficiency in the country and make the local authorities aware of the problem and the necessity of developing programmes to combat anaemia.

The specific objective of this study during this year was to measure iron bioavailability from common diets.

2. EXPERIMENTAL METHOD

Subjects

Eight non- pregnant women and five men in apparent good health ranging in ages from 26 to 45 years old, residents in Lima participated. Written informed consent was obtained from each volunteer subject before participation. Approval was obtained from the Ethical Committee of the Instituto de Investigación Nutricional and from the National Atomic Energy Institute.

Foods

Each volunteer subject consumed the following. Breakfast: coffee (1 cup 300 ml with 2.6 g instant coffee and 21.3 g brown sugar), 2 bread rolls of 27.5 g each with 5 g butter. Lunch: Vegetable soup 150 g and 150 g of rice with cow tripe stew. Lemonade: 200 ml, lemon juice (9 ml) with 10 g of sugar. Dinner: vegetable soup 417 g, with 2 bread rolls 28 g each. Meals were prepared in the Institute's kitchen according to the recipes obtained from the study.

Absorption measurements

On day 1, a venous blood sample was obtained to determine hemoglobin then they were given an aqueous solution of ferrous sulphate 3 mg containing a 2:1 molar ratio of ascorbic acid to iron, labeled with $^{59}FeCl_3$ 1.5 μCi as a drink, 3 hours later they consumed a porridge made by mixing the vegetable soup with the rice and cow tripe, labelled with 5 μCi of $^{55}FeCl_3$.

On day 14. A venous blood sample was obtained to measure the radioactivity incorporated into erythrocytes. Then they received coffee 300 ml and 2 rolls (55 g) with butter (10 g) labelled with 1.5 μCi of $^{59}FeCl_3$. Three hours later they ate a vegetable soup 400 g with 2 rolls (55 g) labelled with 5 μCi of $^{55}FeCl_3$.

On day 28 a venous blood sample was taken in order to calculate the increase in radioactivity between days 14 and 28.

All test meals were eaten after 10 hrs fast in the morning, only water was allowed for 3 hours following the test foods. Blood sample was analysed according with the method of Eakins and Brown [13]. The activity of radioisotopes was analysed with a liquid scintillation counter (Tri-Carb Packard). The percentage absorption was calculated on the assumption that 100% of the absorbed radioactivity was present in the hemoglobin. Blood volume of each subject was calculated by sex weight and height according to Nadler [16]

Statistical analysis

Iron absorption is expressed as percentage of the administered dose. Results are expressed in Mean and 1 Standard deviation. Comparison of absorption of a pair of diet between the same subject was done by t test.

3. *RESULTS OBTAINED*

Table I shows the main characteristics of the volunteers in the study. Table II, shows the nutritional content of the tested meals. Total iron intake is rather low compared with requirements.

Bioavailability of iron in lunch was good and was significantly different from dinner and breakfast (see Table III). We cannot conclude if the low iron absorption from bread is affected by coffee.

Despite low iron content in the meals, absorption was good in lunch possibly due to the action of the promoters ascorbic acid and heme iron.

4. CONCLUSIONS

1. The improvement of iron intake through an iron fortification strategy is the best approach to combat iron deficiency in Peru.

2. Total iron content of these common foods is low. However absorption can be improved by the consumption of ascorbic acid and a small amount of heme iron.

5. PLANS FOR FUTURE WORK

1. To continue with the study of iron absorption from other common diets.

2. To evaluate iron absorption from the meals after adding extra iron to the food vehicle (bread).

3. To evaluate iron bioavailability in weaning foods (in adult models).

4. To evaluate iron bioavailability at high altitudes.

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TABLE I. CHARACTERISTICS OF THE SUBJECTS

CODE	SEX	AGE	WEIGHT Kg.	HEIGTH m.	HEMOGLOBIN Gr/dl
10	F	36	67	158.4	14.5
11	F	35	57	157.9	12.1
12	F	28	53.5	151.9	12.4
13	F	40	59	173.3	12.6
14	F	27	52	157.6	12.1
15	F	40	67	164.4	11.3
16	M	32	64	177.2	14.98
17	F	25	64	163.8	13.4
18	F	37	54	151.4	13.9
19	M	45	81	175.6	12.6
20	M	28	70	178.0	16.0
21	M	37	63	173.8	14.4
22	M	30	85	176.6	14.9

TABLE II. NUTRITIONAL CONTENT OF COMMON PERUVIAN MEALS

MEALS	Calories	Protein g	Fat g	Iron mg	Vit-C mg
Breakfast	317	4.7	8.21	1.1	0.6
Lunch	768	23.7	21.09	3.2	28.1
Dinner	239	10.6	5.9	1.0	4.7
TOTAL	1324	39.0	35.2	5.3	33.4

TABLE III. IRON ABSORPTION FROM MEALS (% OF DOSE)

CODE	Ferrous ascorbate	Lunch	Breakfast	Dinner
10	26.88	7.43	4.7	4.27
11	38.30	47.22	13.59	7.36
12	18.81	-	8.9	11.49
13	2.94	5.79	2.2	3.92
14	8.17	12.56	4.84	2.2
15	21.71	19.11	7.64	5.11
16	14.07	13.31	-	4.4
17	23.90	12.1	0.45	1.68
18	14.22	9.74	4.48	4.46
19	10.4	9.21	0.92	7.85
20	10.34	16 63	1.56	6.11
21	2.01	8.4	0.21	1.0
22	9.29	14.37	0.92	6.79