A stable isotope study in Peruvian women demonstrates higher iron bioavailability in a yellow fleshed potato variety compared to a high iron purple fleshed potato

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Abstract

Iron bioavailability from a yellow fleshed potato (YFP) variety and a high iron purple fleshed potato (PFP) clone was determined using stable isotopes in iron deficient women from Huancavelica, Peru.
Thirty-six participants consumed 2 series (one of each potato type) of 10 test meals on consecutive days. Each meal consisted of 500 g of boiled, peeled and grated potatoes, served as breakfast, and labeled with 0.5 mg of ^{57}Fe (YFP variety) or ^{58}Fe (PFP clone). The feeding sequence was randomized. Fractional iron absorption (FIA) was calculated from iron isotope ratios measured in red blood cells 14 days after the last labelled meal.
Mean FIA from the YPP variety (29%) was higher than in the PFP clone (13%) ($P<6x10^{-15}$). Lower iron absorption in the PFP is very likely caused by its the higher phenolic concentration. The total iron absorbed (TIA) in the purple fleshed clone was not significantly different from the yellow fleshed variety (P= 0.783). However, it is expected that FIA and TIA from a yellow fleshed biofortified clone will be higher and make a significant contribution towards reducing anaemia.

Introduction

During the last 15 years, the International Potato Center has made a considerable progress in increasing the iron concentration of potato through conventional breeding (1).
Potato iron bioavailability was predicted to be high due to the relatively low phytate and high ascorbic acid content in comparison to cereals but no human studies were carried out to test this hypothesis. A recent study, showed that in vitro iron bioaccessibility for potato ranged from 63-79%, a higher value compared to the in vitro bioaccessibility in pearl millet, different types of beans, and rice (6-24%)(2).
The aim of this study was to assess iron bioavailability from a YFP variety vs a high iron PFP clone in women from Peruvian highlands by measuring iron stable isotope incorporation into erythrocytes after consumption of multiple labeled test meals.

Materials and Methods

Study site: The study was conducted in Huancavelica, a city in the central highlands of Peru at 3600 meters during June and August 2019.

Participants: Young women from Huancavelica, aged 18 to 45 years. Mainly students who voluntarily decide to participate.

Study design

- Randomized cross over double blind study.
- Every woman received 2 different types of potato meals in series of 10 servings for 5 day each. The order of the 2 different series was randomized.
- Each meal consisted of 500 g of boiled, peeled and grated potatoes, served as breakfast.
- One potato meal was based in the YFP (local variety Peruanita) and the other in the high iron PFP (306417.79) clone labeled with 0.5 mg of ^{57}Fe or ^{58}Fe, respectively.
- Blood samples were drawn at day 1, 15, 26 and 40.
- FIA was calculated from iron isotope ratios measured in red blood cells 14 days after the last labelled meal.

Results and Discussion

Potato test meal composition.

The average daily consumption of the YFP and high iron PFP meals was around 500 g, resulting in a daily intrinsic iron intake of 1.63 mg from the YFP meal and 3.47 mg from the PFP meal. Both meals contained some phytic and ascorbic acid and high concentrations of polyphenols (PP, being 3.5-fold higher in the PFP meal compared to the YFP meal.

Table 1. Composition of potato test meals

Test meal type	yellow-fleshed potato Peruanita mg / 100 g	purple-fleshed potato clone 306417.79 mg / 100 g
Iron native	0.33 ± 0.03	0.69 ± 0.07
Ascorbic acid	8.8 ± 2.5	12.70 ± 1.30
Phytic acid[2]	4.8 ± 0.9	31.7 ± 5.1
Total phenolics	29.6 ± 2.3	105.6 ± 7.9
Calcium	5.4 ± 0.6	7.3 ± 0.5

Fractional and total iron absorption.

- FIA (geometric mean; 95% CI) was significantly higher ($p<0.001$) in the YFP meal (28.4; 23.5, 34.2) compared to the high iron PFP meal (13.3; 10.6, 16.6).
- TIA in mg/day (geometric mean; 95% CI), was not different ($p=0.88$) between the YFP (0.46; 0.38, 0.56) and high iron PFP meal (0.46; 0.37, 0.57) covering 33% of the median daily iron requirement for absorbed iron in women of reproductive age.

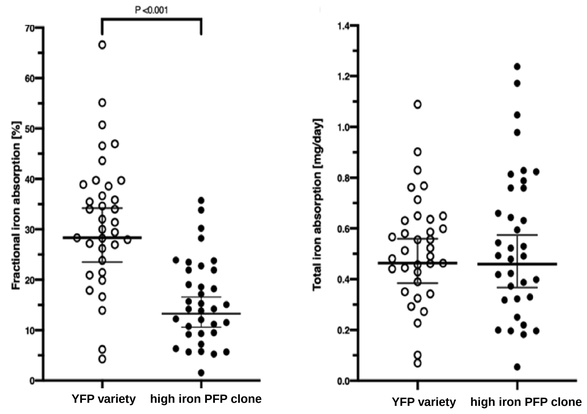

Figure 1. FIA and TIA from both potato meals

The FIA from high iron PFP (13.3%) was half of that from the YFP variety (28.4%), resulting in the same daily quantity of iron absorbed (0.46 mg).
The FIA of the YFP and PFP test meal was above the expected 5-10% for plant-based diets when consumed as a single food test meal as it is commonly consumed in the Latin American highlands.

The lower FIA from the high iron PFP meal may be explained by its higher PP content (528 mg / 500g) compared to the YFP variety(148 mg / 100g).

The phenolic profile of both types of potatoes (Table 2) shows that phenolic acids (chlorogenic acid, its isomer and caffeic acid) as well as anthocyanins and tryptophan are significantly higher in the PFP and could play a significant role in reducing iron absorption. However we need a study to evaluate and determine which phenolic has the main role on inhibiting iron absorption in potatoes.

Table 2. Phenolic profile of the YFP and PFP

Test meal type	yellow-fleshed potato Peruanita mg / 100 g, FW	purple-fleshed potato clone 306417.79 mg / 100 g, FW
Total anthocyanins	0	17.46 ± 1.09
Chlorogenic acid	8.59 ± 1.84	34.02 ± 1.09
Neochlorogenic acid	0.91 ± 0.33	5.00 ± 0.42
Cryptochlorogenic acid	1.72 ± 0.52	6.86 ± 0.43
Caffeic acid	0.16 ± 0.05	0.68 ± 0.08
Tryptophan	4.66 ± 0.81	11.45 ± 2.84
Rutin	0.25 ± 0.10	0.04 ± 0

Conclusions

- Iron bioavailability from YFP is remarkably high.
- Iron absorbed from both potato test meals covered 33% of the daily absorbed iron requirement for women of reproductive age.
- High polyphenol levels were likely the major inhibitors of iron absorption.
- Iron biofortification on potato should target also for lower polyphenol and higher ascorbic acid content in order to increase the iron absorption.

Further Research needed

- Evaluate human iron bioavailability from yellow fleshed iron biofortified potatoes vs a yellow fleshed potato variety using stable isotopes.
- Evaluate potato iron bioavailability in humans considering potato consumed as a component of a meal
- Determine potato iron bioavailability in target populations based at lower altitudes to confirm high iron bioavailability from potatoes.
- Determine which phenolic has the main role on inhibiting iron absorption.

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