Lentils (*Lens culinaris* L): A Whole Food Solution for Micronutrient Malnutrition

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INTRODUCTION

Micronutrient malnutrition affects more than two billion people worldwide. Particularly vulnerable are women and preschool children in south Asia, Africa and Latin America. Micronutrient malnutrition has been addressed through food fortification, dietary supplementation and bio-fortification of staple crops, but to date such programs have had limited success. Sustainable solutions to malnutrition in general, including micronutrient malnutrition, calls for better linking food systems with the dietary needs of people. The biofortification approach holds great promise for improving the nutritional, health, and socioeconomic status of people around the world. One of our key research goals at the North Dakota State University - Pulse Quality and Nutrition Program is to understand the genetic potential of lentils, field peas, and chickpeas for biofortification of bioavailable micronutrients to combat global micronutrient malnutrition. In this article, we (1) provide an overview of Fe, Zn, Se and beta carotene concentrations in lentil; (2) review the role of phytic acid and prebiotics on mineral bioavailability; (3) share preliminary results of the clinical nutrition research from Sri Lanka.

METHODS

We have used a series of analytical methods using high performance liquid chromatography (HPLC) with photodiode array detection (PDA), pulsed amperometric detection (PAD), and conductivity detection, atomic absorption spectroscopy (AAS), and inductively coupled plasma-mass spectrometry (ICP-MS), and x-ray absorption spectroscopy techniques to determine the concentration and speciation of mineral micronutrients, beta carotene, prebiotic carbohydrates, and phytic acid in lentils.

RESULTS AND DISCUSSION

Iron, zinc and selenium

Our previous research from Canada highlighted the micronutrient value of pulse crops (Thavarajah et al., 2011). The total Fe concentrations in lentils ranged from 73 to 90 mg Fe kg^{-1}. For example, 100 g of lentils can provide a minimum of 91-113% of the recommended daily allowance (RDA) of Fe for males and 41-50% for females. Zn concentrations in lentils ranged from 44-54 mg Zn kg^{-1}. A single serving of lentils could provide 40-49% of the RDA of Zn for males and 55-68% for females. The total Se concentration in lentils grown in Canada ranged between 425 and 673 µg kg^{-1}, with 100 g of dry lentils providing 77-122% of the RDA. Lentils are therefore a good source of daily Fe, Zn and Se.

Mineral micronutrient concentrations in lentils vary with soil mineral content. Comparison of international lentil samples showed high lentil Fe concentrations from Syria (63 mg kg^{-1}), Turkey (60 mg kg^{-1}), USA (56 mg kg^{-1}), and Nepal (50 mg kg^{-1}), and the lower concentrations from Australia (46 mg kg^{-1}) and Morocco (42 mg kg^{-1}). For Zn, lentils grown in Syria (36 mg kg^{-1}), Turkey (32 mg kg^{-1}), and USA (28 mg kg^{-1}) had the highest concentrations and Australia (18 mg kg^{-1}) and Morocco (27 mg kg^{-1}) were the lowest. The high Fe and Zn lentil varietal release by ICARDA with Harvest Plus in 2005 might have led to higher Fe and Zn concentrations in Syrian crops. A survey of Se concentrations in lentil genotypes grown in eight major world regions indicated considerable variation; Nepal and Australia had higher Se concentrations of 180 and 148 μg kg^{-1}, respectively while Syria, Morocco, and Turkey had the lowest (22, 28, and 47 μg kg^{-1}, respectively).

Beta-carotene

Pulses are naturally rich in carotenoids. Our preliminary analyses indicated lentils grown in North Dakota, USA have high concentrations (2-12 μg g^{-1}) of beta carotene. Consumption of 100 g of lentils could potentially provide daily beta-carotene requirements.

Phytic acid

Phytic acid (PA) is an anti-nutrient; high PA levels reduce mineral bioavailability. Lentils are naturally low in PA (2.5-4.4 mg g^{-1} or physic acid P levels of 0.7 to 1.2 mg g^{-1}). These levels are lower than low phytic mutants of 1.22-2.23 mg g^{-1} for rice, 1.77-4.86 mg g^{-1} for soybean, 1.24-2.51 mg g^{-1} for wheat, 3.3-3.7 mg g^{-1} for maize, and 0.52-1.38 mg g^{-1} for common bean. Low PA is a favorable factor to increase lentil mineral bioavailability.

Prebiotics

Fructooligosaccharides (FO) are modulating digestive tract environments to increase mineral bioavailability. The total FO levels for 10 lentil genotypes grown in 2010 from three locations in ND, USA ranged from 1320-2088 mg 100 g^{-1} of lentils; at these levels, these US-grown lentils could provide a minimum of 40% of the recommended daily intake (RDI) of fructooligosaccharides. Provision of FO rich lentils could increase mineral bioavailability.

Clinical trail

Bioavailability studies using *in vitro* digestion/Caco-2 cells and human models showed certain lentil genotypes (e.g., CDC Milestone and CDC Redberry) are rich in highly bioavailable Fe and Se (Thavarajah et al. 2011). The Caco-2 cell culture studies indicate Fe in lentils is highly bioavailable; higher than that of common bean, wheat, or finger millet.

CONCLUSIONS

The nutritional benefit of pulses as a part of the diet has long been known. However, intensive work recently carried out on lentil within global mineral biofortification efforts has highlighted its superior nutritional profiles: lentils are a rich source of highly bioavailable minerals possibly due to their favorable food matrix factors; high in carotene and prebiotics and low in phytates. Lentils cook faster (less than 10 minutes), and is therefore a better solution to reduce energy and cooking time demands. Our research clearly shows lentils could be an ideal crop that could be targeted for micronutrient biofortification and a possible whole food solution to the global micronutrient malnutrition.

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