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Applied nutritional investigation

Potential contribution of African green leafy vegetables and maize porridge composite meals to iron and zinc nutrition

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ABSTRACT

Objectives: The aim of this study was to determine the mineral nutritive value of different traditional African green leafy vegetable (GLV) dishes and their composite meals with fortified and unfortified maize porridge.
Methods: The mineral (iron, zinc, and calcium) and antinutrient (phytate, total phenolics, and tannins) contents and in vitro bioaccessibility of iron and zinc were analyzed. The iron and zinc contents and bioaccessibilities were used to calculate contribution these dishes and meals could make toward the recommended daily requirements and absolute requirements of vulnerable populations.
Results: It was found that the GLV dishes contained average amounts of zinc (2.8–3.2 mg/100 g, dry base [db]), but were high in both iron (12.5–23.4 mg/100 g, db) and antinutrients (phytate 1420–2089 mg/100 g, db; condensed tannins 105–203 mg/100 g, db). The iron bioaccessibility and amount of bioaccessible iron ranged between 6.7% and 45.2% and 0.9 and 5.11 mg/100 g, db, respectively. The zinc bioaccessibility and amount of bioaccessible zinc ranged between 6.4% and 12.7% and 0.63 and 1.63 mg/100 g, db, respectively.
Conclusion: Importantly, although compositing the GLV dishes with fortified maize porridges decreases the iron and zinc contents, because of the low antinutrient content of the maize meal, the amount of bioaccessible iron and zinc in the meal increases.

Introduction

Anemia, of which the major cause is iron deficiency, affects 1.62 billion individuals globally [1]. Zinc deficiency has also been identified as a global public health problem, causing 1.4% of all deaths worldwide [2]. Large proportions of households in sub-Saharan Africa, where iron and zinc deficiencies are prevalent, depend on monotonous cereal-based diets for energy as well as micronutrients [3]. These diets contain phytate and sometimes tannins, which, even further reduces the already low bioavailability of the non-heme iron and zinc in the diet [4].

Commercial food fortification is often regarded as one of the most successful and cost-effective public health approaches for preventing micronutrient malnutrition [5], as it is a practical, sustainable, cost-effective long-term solution [6]. In recent years, in the developing world, food fortification has become an increasingly attractive option and programs are moving to the implementation phase very rapidly [7]. It has, however, long been recognized that a combined approach should be used in the fight against malnutrition, and that dietary diversification with locally available, nutrient-dense foods is very important to ensure sustainable increased nutrient intake [8].

It has been proposed that traditional, often wild-growing, African green leafy vegetables (GLVs), can play a major role in enhancing the nutritional value of diets [3] and improving household food and nutrition security [9] in sub-Saharan Africa. Compared with traditionally cultivated GLVs (cabbage, spinach, and kale), these traditional African GLVs are better adapted to harsh weather conditions, more resistant to pests

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and pathogens [10], and have similar or improved nutrient contents [3]. Most importantly, these wild-growing vegetables are freely available to some of the poorest households and communities.

There is, however, a lack of information available on the cooking and preservation methods, as well as the nutrient composition of traditionally consumed GLV dishes [11]. Consequently, information on the bioaccessibility of nutrients from GLVs, their respective dishes and total meals, are also very limiting [3,9]. Importantly, for in vitro mineral bioaccessibility data to be most closely related to human bioavailability, food analyzed should be prepared as consumed [12]. In sub–Saharan Africa, GLV relishes and dishes are often consumed with staple grain porridges [3]. Because maize, consumed in the form of porridge, is the most important staple [13] of some vulnerable populations in Africa, it is a popular choice for national food fortification programs [7], as is the case in South Africa [14].

To our knowledge, no research has been published on the bioaccessibility of iron and zinc from traditionally consumed African GLV dishes alone or in maize porridge composite meals. This study aimed to determine the mineral nutritive value of different GLV dishes and their composite meals with maize porridge. It also aimed to assess the bioaccessibility of iron and zinc from GLV dishes, composed of various commonly consumed GLVs, alone and composited with maize porridge. The effect of maize meal fortification on the iron and zinc bioaccessibility from GLV–maize porridge composite meals was also investigated. Finally, the results were used to calculate the contribution these GLV dishes could make to the required iron and zinc intake (recommended dietary allowance [RDA]) of vulnerable populations. The contribution that could be made to the absolute iron and zinc requirements (amount of required bioavailable iron and zinc) of vulnerable populations was also estimated.

Materials and methods

Materials preparation

GLV dishes

The GLVs were cultivated on farmland approximately 50 km outside Potchefstroom (South Africa) from October 2011 to February 2012. Representative samples of the GLV dishes made and spread over the entire harvesting period were combined and processed (see Fig. 1). The dishes were frozen, freeze-dried, and stored airtight at −20°C until analyzed.

Fortified and unfortified maize porridge

The commercial, special grade-fortified maize meal was donated by South African grain laboratories in July 2014, and fortification was confirmed according to South African regulation (iron 3.5 mg/100 g; zinc 1.5 mg/100 g) [14]. The commercial, special grade, non-fortified maize meal (donated by Foodcorp in June 2013) was taken out of a commercially milled batch before the mandatory fortification premix was added. The maize meal was stored in airtight containers at 5°C to 9°C until use.

For the preparation of the stiff porridges, a paste was made from maize meal (15 g) and cold deionized water (10 mL), which was added to boiling deionized water (200 mL). This mixture was cooked for 10 min; 30 g of maize meal was added and cooked for an additional 10 min. The fortified and unfortified porridge samples were frozen, freeze-dried, and stored airtight at −20°C until analyzed.

GLV–maize porridge composite dish

GLV–maize composites were prepared according to the proportions eaten by school children in an earlier intervention study in which children consumed 125 g maize porridge served with 300 g of a GLV dish [17]. In our study, each GLV dish was composited in a meal with both the fortified and unfortified maize porridge respectively at a ratio of 1:2.4 dry base (db).

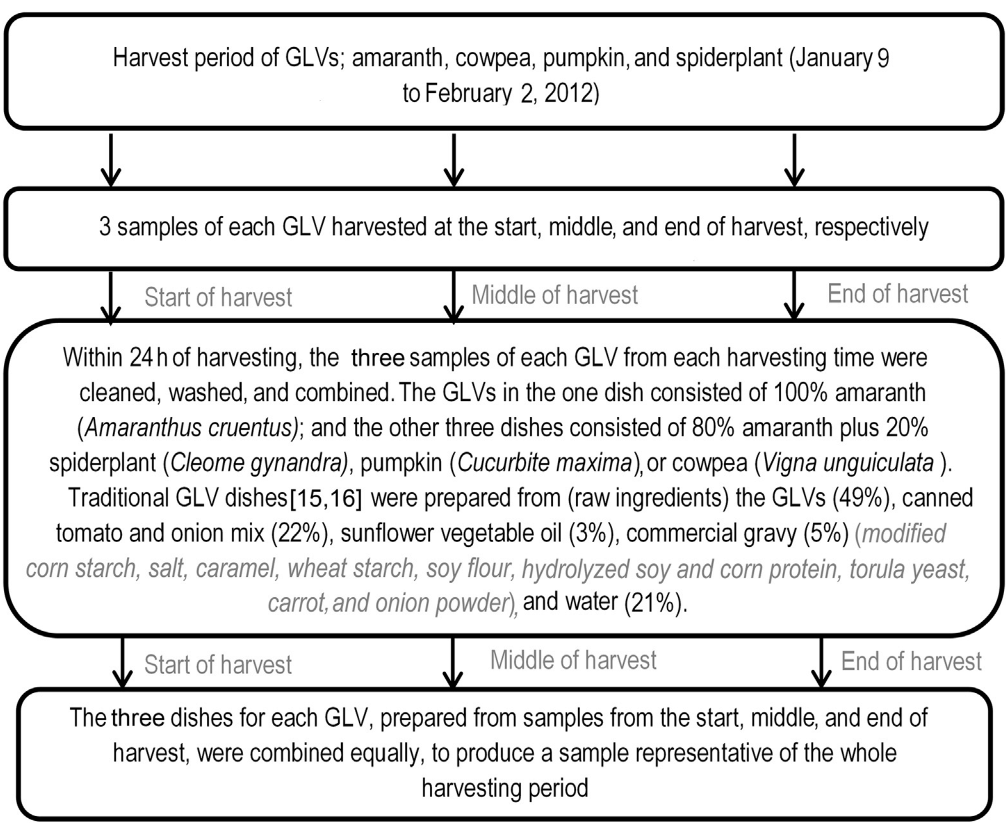

Fig. 1. Harvest and preparation of traditional African green leafy vegetables (GLV) dishes [15,16].