# Zinc fortified biscuits for children

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Over three-billion people worldwide are afflicted with micronutrient malnutrition, caused largely by a dietary deficiency of vitamins and minerals. Zinc deficiency is endemic amongst developing countries, and Ethiopia is no exception. Zinc deficiency triggers many health problems in children, many of which can become chronic, such as weight loss, stunted growth, weakened resistance to infections, and mortality.

Eragrostis tef (teff) is a small seeded millet-like cereal grain indigenous to Ethiopia. Teff, a high-iron cereal crop, is one of the staple cereals in Ethiopia and is used to prepare starchy fermented foods such as injera (fermented sourdough flat bread), porridge and alcoholic beverages. Nutritional iron deficiency is not a serious problem in Ethiopia but zinc deficiency remains highly prevalent, especially in children.

**"To prevent or alleviate zinc deficiency in Ethiopian children, our group developed a biscuit made from teff flour and fortified with zinc lactate."**

*Pamela Dovi, Lauren Smith and Courtney Robertson*

Zinc deficiency is largely related to dietary inadequacies, which can be attributed to low intakes of zinc and poor bioavailability. The diets of rural populations in most developing countries are based on unrefined cereals and legumes rich in phytate. Phytic acid (myo-inositol hexaphosphate – IP6) has a strong affinity to chelate multivalent metal ions, especially iron, zinc, and calcium. The chelates formed give rise to insoluble complexes in the gastrointestinal tract that cannot be digested or absorbed in humans.

To prevent or alleviate zinc deficiency in Ethiopian children aged between three and 13 years, our group developed a biscuit made from teff flour and fortified with zinc lactate. Zinc lactate was the chosen fortifying substance because it is a natural product and able to contribute a relatively mild flavour with sufficient solubility and a large amount of free zinc ions.

In order to reduce the phytate content of the flour, three major processing steps were considered: 1) fermentation, 2) milling and 3) heat processing during baking of the biscuits. The biscuit concept was proposed because children of three years and older have outgrown the complementary food (baby porridge) stage. Children are then expected to consume the same phytate-rich plant-based foods as those consumed by the rest of the family. Children, however, are still growing at accelerated rates at this young age and it is imperative that their zinc requirements are met every day to prevent long-term adverse health effects.

Proximate analysis revealed that our biscuits had a very low moisture content (two per cent), signifying microbiological stability (low aw) and a long shelf life if packaged and stored correctly. The protein and carbohydrate content were five per cent and 70 per cent respectively. The fat content of the biscuits was fairly high (20 per cent), but beneficial for undernourished children. The zinc content of the biscuits was determined through flame atomic absorption spectrophotometry. The average zinc


***Teff$^{Zn}$ biscuits are zinc fortified biscuits developed for children between the ages of three and 13***

value was 368,42 mg/kg. Therefore one biscuit weighing 11,4 g will contain 4,2 mg of zinc. The zinc recommended daily allowance (RDA) for children aged three to eight years is 5 mg zinc/day, and children aged nine to 13 years require 8 mg zinc/day. If the serving portion is two biscuits per child per day, each child will receive 8,4 mg zinc/day. Thus, we had achieved the zinc RDA for children between the ages of three and 13 years.

Achieving the zinc RDA in our Teff$^{Zn}$ biscuits would have been an empty promise if the phytates interfered with the zinc bioavailability. The phytate content of teff bran, teff flour (endosperm), fermented teff flour and our Teff$^{Zn}$ biscuit samples were determined through anion exchange chromatography. Separating the bran and endosperm layers through milling of the teff grain did not reveal a significant difference (2 mg/g flour) in phytate content. The phytate content of the bran samples was the highest (18,5 mg/g flour), which was to be expected as most of the phytates are in the aleurone layer. The reason for this could be that the teff grain is so small that it is extremely difficult to completely separate the aleurone and bran layers from the endosperm during roller milling. Fermentation reduced the phytate content significantly, almost a six-fold reduction between the bran sample and the fermented flour sample (3,8 mg/g flour). Fermentation leads to lowering of pH, a consequence of bacterial production by lactic and acetic acids, which is favourable for phytase activities, resulting in lowering of phytate. However, our preliminary biscuit formulation using the fermented flour had a sour taste and undesirable aroma. Therefore, baking of our Teff$^{Zn}$ biscuits using endosperm white teff flour (16 mg/g flour) showed a reduction of about 5mg/1g flour of phytic acid, proving that heat processing is an alternative step in breaking down the phytates. Thus, the phytate content of our Teff$^{Zn}$ biscuit was 11mg/g biscuit.

The mean phytate:zinc molar ratio may be used to classify diets as having low or average zinc bioavailability. A phytate:zinc molar ratio of <5 represents a high bioavailability. Teff$^{Zn}$ biscuits scored a 2,97, indicating that our Teff$^{Zn}$ biscuits are capable of contributing towards the zinc RDA of children.

Our Teff$^{Zn}$ biscuits have three important characteristics distinguishing them from other biscuits on the market. The biscuits are teff-based, gluten-free and zinc fortified. The formulation is also cost-effective, at only 14c per biscuit. To our knowledge, there is currently no other biscuit on the market offering all three of these characteristics. The main competition would be the gluten-free market, in which our product could perform substantially well because of the uniqueness of our ingredients and flavour profiles, as well as supporting the Ethiopian economy in exporting a value-added product into developed countries.

Allen Davis once said, 'We are indeed much more than what we eat, but what we eat can nevertheless help us to be much more than what we are.' A sweet, nutty tasting Teff$^{Zn}$ biscuit could prevent and help to alleviate zinc deficiency amongst vulnerable children, ensuring them a better future. □

***Teff$^{Zn}$ could alleviate zinc deficiencies amongst Ethiopian children***