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EFFECT OF SOME POST-HARVEST TREATMENTS ON THE BIOAVAILABILITY OF ZINC FROM SOME SELECTED TROPICAL VEGETABLES

A.A. Akindahunsi[1]
Biochemistry Department, Federal University of Technology,
P.M.B. 704, Akure, Ondo State, Nigeria[2]
and
The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy

and

G. Oboh
Biochemistry Department, Federal University of Technology,
P.M.B. 704, Akure, Ondo State, Nigeria.

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[1] Regular Associate of the Abdus Salam ICTP and corresponding author.
Address until 9 May 1999: Associate Office, the Abdus Salam ICTP. P.O. Box 586, I-34100 Trieste, Italy. E-mail: aakin@ictp.trieste.it
[2] E-mail: aakin@futa.edu.ng

Abstract

The effect of three post-harvest treatments namely, sun-drying, oven-drying (75 and 100 °C) and blanching at 100 °C for 5 min. on the bioavailability of zinc from some selected tropical vegetables was investigated. Phytate, zinc, and calcium contents of six vegetables namely, cock's comb, water leaf, long fruited jute, bitter leaf, Indian spinach and bush green were analyzed and their phytate:Zn, Ca:phytate and [Ca][phyate]/[Zn] molar ratios calculated.

Though the phytate levels (mg/100 g) obtained were high (1128.2-2752.9), the levels were further increased by the post-harvest treatments except blanching which actually brought about reduction (33.3-65.0 %). On the other hand, the calculated phytate:Zn molar ratio was generally lower than the critical value of 15:1. However, while sun-drying and oven-drying at both 75 and 100 °C gave high figures for the calculated [Ca][phyate]/[Zn] molar ratios, 5 min. blanching at 100 °C gave normal figures for this ratio, except water leaf. Bitter leaf (Vernonia amygdalina Del) recorded the least values for the three ratios, thus indicating this vegetable as the best source of zinc.

The results of the present study indicate a reduced zinc bioavailability from vegetables by such post-harvest treatments as sun-drying and oven-drying compared to the excellent performance of blanching.

INTRODUCTION

It is well known that zinc is one of the essential trace elements for human nutrition [1]. Pregnant adolescents have very high zinc requirements to support the developing fetus and to maintain skeletal maturation after menarche [2]. Children, however, appear to be more vulnerable to sub-optimal zinc status, presumably because of their high zinc requirements for growth [3].

The importance of a foodstuff as a source of dietary zinc depends upon both the total zinc content and the level of other constituents in the diet that affect zinc bioavailability. Phytic acid (myo-inositol 1,2,3,4,5,6-hexakis dihydrogen phosphate) may reduce the bioavailability of dietary zinc by forming insoluble mineral chelates at physiological pH [4]. The inhibitory effect of phytate on zinc absorption [5] has been quantified by the molar ratios of phytate to zinc in the diet [6]. Ratios greater than 20 have been associated with biochemical and/or clinical evidence of zinc deficiency [7]. Calcium potentiates the inhibitory effect of phytate on zinc absorption, even at relatively low amounts of dietary phytate.

The importance of adequate levels of essential trace elements in human diets is well recognized. However, most of the recent dietary trace element studies have been conducted on population groups from developed countries [8]. This is unfortunate because the first cases of human trace element deficiency were described in the third world countries [9]. The dearth of data on dietary trace element intakes of non-industrialized countries is probably due to the lack of information on the trace element values of local foodstuffs. The present study, therefore, sought to investigate the effect of some post-harvest treatments on the bioavailability of zinc from some selected tropical vegetables.

MATERIALS AND METHODS

Sample Collection

Samples of six vegetables were collected from farms around the Federal University of Technology, Akure, Nigeria. Edible portions of each variety were divided into four. One portion was sun-dried (approximately 3 days), the second and third portions were oven-dried at 75°C and 100°C, respectively (overnight) while the fourth portion was blanched at 100°C for 5 min.

Laboratory Analysis

Approximately 2g of each powdered sample was dry-ashed at 500^0C. The zinc and calcium contents were determined on aliquots of the solutions of the ash by established flame atomic absorption spectrophotometry procedures using a Perkin-Elmer atomic absorption spectrometer (Model 372) [10]. Lanthanum chloride (1%) was added to both samples and standard solutions for calcium determination to overcome phosphorous interference. Phytate was determined in triplicates using the method of Wheeler and Ferrel [11].

RESULTS

Levels (mg/100g) of phytate, zinc, and calcium and calculated phytate:Zn, Ca:phytate and [Ca][phyate]/[Zn] molar ratios, expressed on a dry weight basis for sun-dried, oven-dried and blanched vegetables are presented in Tables I, II and III, respectively.

The vegetables analyzed recorded high levels (mg/100 g) of phytate, ranging from 1128.2 (long fruited jute) to 2752.9 (bush green). These levels were further increased by sun-drying (57.7 - 223.6 %), 75°C oven-drying (47.5 - 328.9 %), 100°C oven-drying (70.1 - 332.5 %) but blanching caused reduction (33.3 - 65.0 %). Sun-drying caused increase in the levels of the minerals except cock's comb and Indian spinach. On the other hand, the other treatments brought about reduction in the level of zinc (1.7 - 64.2 %).

Bitter leaf recorded the least values for the three molar ratios namely, phytate:zinc (0.3), calcium:phytate (12.8) and [Ca][phytate]/[Zn] (0.1). The highest values were recorded by water leaf (2.9), Indian spinach (74.7) and water leaf (5.2) for phytate:zinc, calcium:phytate and [Ca][phyate]/[Zn] molar ratios, respectively. The levels of the three molar ratios were increased by the treatments except blanching which actually brought about reduction.

DISCUSSION

The nutritional adequacy of dietary zinc depends on both the amount and bioavailability in the diet. The effect of dietary phytate on the bioavailability of zinc depends on the amount of calcium in the diet relative to phytate [12].

The levels of phyate (1128.2-2752.9) obtained in the present study were generally higher than the figures obtained by Ferguson et al. [12] working on East African foods. This may be due to varietal and / or locational differences. On the other hand, levels of zinc were comparable to, while those of calcium were generally high compared to Ferguson et al. [12]. Blanching caused reduction in the levels of the minerals analyzed probably due to leaching [13].

The three calculated molar ratios were least in bitter leaf (Vernonia amygdalina Del), thus indicating this vegetable as the best source of zinc among the six vegetables investigated. The calculated phytate:Zn molar ratio was lower than the critical value of 15:1 [5] while the calculated Ca:phytate molar ratio was higher than the critical value of 6:1 [12] for the three treatments. However, the trend was made clearer by the calculated

[Ca][phyate]/[Zn] molar ratio. While sun-drying and oven-drying (75 and 100^{0}C) gave high values, blanching gave normal values for this ratio except water leaf. It is very important to note that the [Ca][phyate]/[Zn] molar ratio is considered a better predictor of increased relative risk of reduced zinc bioavailability compared with the phyate:Zn ratio because of the Ca-to-phytate interaction [14].

The results of the present study indicate reduced zinc bioavailability from vegetables occassioned by sun-drying and oven-drying at various temperatures while blanching improved the nutritional potentials of the leafy vegetables investigated. This result is of particular significance considering the popularity of the post-harvest drying treatments amongst Nigerians. This should be discouraged if the full nutritional potentials of the greens (considered a good alternative to animal sources which are rather expensive) are to be realized, particularly by populations in the developing world.

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Table I. Analyzed values (mg/100 g DW) of phytate, Zn, and Ca and calculated phytate:Zn, Ca:phytate and [Ca][phytate]/[Zn] molar ratios for some selected sun-dried tropical vegetables

Vegetable	Phytate	Zn	Ca	Phy:Zn	Ca:Phy	[Ca][phy]/[Zn][a]
Cock's comb/	3751.3	226	9241	1.6	40.7	3.8
Celosia ergentea	(2143.6)[b]	(530)	(8940)	(0.39)	(68.8)	(0.1)
Water leaf/	7576.0	94	7560	7.9	16.5	15.0
Talinum triangulare L	(2341.1)	(80)	(7170)	(2.9)	(50.5)	(5.2)
Long fruited jute/	2549.8	245	10740	1.0	69.5	2.8
Corchorus olitorious	(1128.2)	(190)	(1057)	(0.6)	(15.5)	(0.2)
Bitter leaf/	2312.9	536	11530	0.4	82.3	1.2
Vernonia amygdalina Del	(1466.7)	(530)	(1139)	(0.3)	(12.8)	(0.1)
Indian spinach/	6374.4	87	8420	7.2	21.8	1.3
Basella alba	(2030.8)	(220)	(9200)	(1.0)	(74.7)	(2.1)
Bush green/	4371.9	691	11233	0.6	42.4	1.7
Amaranthus hybridus	(2752.9)	(540)	(10980)	(0.5)	(65.8)	(1.4)

[a]mol/kg
[b]values in parenthesis refer to fresh samples

Table II. Analyzed values (mg/100 g DW) of phytate, Zn, and Ca and calculated phytate:Zn, Ca:phytate and [Ca][phytate]/[Zn] molar ratios for some selected tropical vegetables oven-dried at 75 and 100 ^{0}C

Vegetable	Phytate	Zn	Ca	Phy:Zn	Ca:Phy	[Ca][phy]/[Zn][a]
Cock's comb/	3824.7	219	8632	1.7	37.2	3.7
Celosia ergentea	(4625.7)[b]	(207)	(8461)	(2.2)	(30.2)	(4.7)
Water leaf/	10041.2	62	6820	15.9	11.2	27.2
Talinum triangulare L	(10125.8)	(50)	(6690)	(19.9)	(10.9)	(33.4)
Long fruited jute/	1664.3	173	10360	0.95	102.7	2.45
Corchorus olitorious	(1985.7)	(168)	(9830)	(1.2)	(81.7)	(2.9)
Bitter leaf/	2369.3	521	11240	0.45	78.3	1.3
Vernonia amygdalina Del	(3328.3)	(503)	(11103)	(0.7)	(55.0)	(1.8)
Indian spinach/	6222.1	83	731	7.4	19.4	13.5
Basella alba	(4682.1)	(74)	(7060)	(6.2)	(24.9)	(11.0)
Bush green/	4710.3	473	1054	1.0	36.9	2.6
Amaranthus hybridus	(4682.1)	(401)	(10312)	(1.2)	(36.3)	(3.0)

[a]mol/kg
[b]values in parenthesis refer to 100 ^{0}C oven-dried samples

Table III. Analyzed values (mg/100 g DW) of phytate, Zn, and Ca and calculated phytate:Zn, Ca:phytate and [Ca][phytate]/[Zn] molar ratios for some selected blanched tropical vegetables

Vegetable	Phytate	Zn	Ca	Phy:Zn	Ca:Phy	[Ca][phy]/[Zn][a]
Cock's comb/ Celosia ergentea	1116.9	190	6030	0.6	89.1	0.9
Water leaf/ Talinum triangulare L	1353.9	63	5820	2.1	70.9	3.1
Long fruited jute/ Corchorus olitorious	394.9	110	8820	0.4	226.9	0.5
Bitter leaf/ Vernonia amygdalina Del	648.7	365	8560	0.2	131.9	0.2
Indian spinach/ Basella alba	1353.9	125	6840	1.1	57.1	1.8
Bush green/ Amaranthus hybridus	1692.3	394	8980	0.4	87.6	0.94

[a]mol/kg