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The Effect of Seasoning Salts and Local Condiments on Mineral Availability from Two Nigerian Vegetables

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Abstract: Seasoning salts have now replaced local condiments in the kitchen of virtually every Nigerian home thus prompting this comparative study on mineral availability from Nigerian vegetables. The iron content of both seasoning salts (*Maggi* and A-one) was higher than that in the vegetables. Fermentation decreased the iron content of African locust bean while that of melon seed was unaffected. The availability of iron was generally high (21-35%) while *Maggi*, *iru* and *ogiri* enhanced iron availability in *Amaranthus* composite diets but iron availability from *Corchorus* composite diets was inhibited. Tannin content in both vegetables was similar but phytate in *Corchorus* was 300% greater than in *Amaranthus*. Fermentation reduced the level of magnesium by 50% in locust bean but increased that of melon seed. The seasoning salts enhanced magnesium availability in *Corchorus* vegetable and was inhibited by locust bean and melon seed. Fermentation improved magnesium availability in condiment-*Corchorus* composite diets. Copper content was high in the plant foods, low but with high availability in the seasoning salts. Fermentation reduced the copper availability in locust bean but increased that of melon seed. Availability of copper was virtually inhibited in all the composite diets. Zinc content of *iru* and *ogiri* was 250% greater than the level in seasoning salts and the vegetables. Zinc availability was high in the vegetables, *Maggi* and low in *iru* and was depressed in *Corchorus* composite diets but enhanced in most *Amaranthus* composite diets.

Key words: *Amaranthus*, *corchorus,* locust bean, melon seed, fermentation, phytate, tannin

Introduction

The discovery of spices in prehistoric times must have been a period of joy for spices generally add flavour to food and in many instances also contribute some nutrients including mineral elements and some vitamins. Initially, spices and condiments are herbs, leaves and or fermented seeds, until the discovery of monosodium glutamate by Kikunae Ikeda in 1907 and its subsequent commercial production in 1908 (www.directfood.net). In Nigeria and most African countries, condiments such as fermented locust bean (*iru*) and fermented melon seed (*ogiri*) were widely used to give flavour and taste to food. The proximate composition indicated that these two condiments could contribute to the protein, lipid and mineral daily intake when used liberally as done in several homes, where the expensive animal product is a luxury (Odunfa, 1981; 1985; Omafuvbe *et al*., 2000, 2002, 2003). Unfortunately, the culinary trend in the developing countries like Nigeria today is towards the use of the cheap and ubiquitous monosodium glutamate based seasoning salts. The application of these seasoning salts, to the detriment of local condiments, in public and private cooking is partly due to a falling standard of living, lack of nutritional information, and the high cost of animal proteins. Two main forms of seasoning salt exist - chicken or beef flavoured salt and the pure (>99%) monosodium glutamate packed for instant use. The latter is the salt of an amino acid, which has been reported to inhibit the binding of iron to neutral detergent fibre (NDF) by 15% thereby enhancing iron availability (Reinhold *et al*., 1981). The basic hypothesis of this study is that the monosodium glutamate salt would also enhance mineral availability as demonstrated by its parent amino acid-glutamic acid.

Mineral deficiency in the third world, where the population subsists mainly on plant foods, can be directly linked to the low availability of the more than adequate minerals present in the staple plant foods. Mineral availability is affected by (a) chemical factors such as the valency, solubility and pH of the aqueous solution of the various elements (Clydesdale and Camire, 1983); (b) the food constituents which could either enhance or inhibit mineral availability. The former category such as ascorbic acid, lactic acid and some amino acids could form soluble chelates (Adewusi *et al*., 1999; Hazell and Johnson, 1987). The antinutritional compounds such as tannin, phytate and oxalate, which are components of plant foods, form high molecular weight complexes of low solubility thus inhibiting

mineral availability (Adewusi and Falade, 1996; Hurrell *et al*., 1999).
The present study is therefore designed to investigate the effect of fermentation on the tannin and phytate content of locust bean and melon seeds during the production of the condiment products and to compare the effect of local condiments with those of selected monosodium glutamate based seasoning salts on the availability of selected minerals from two of the most widely consumed vegetables in Nigeria - *Amaranthus esculentus* and *Corchorus olitorius* (Awoyinka *et al*., 1995).

Materials and Methods

Amaranthus esculentus and *Corchorus olitorius* vegetables and seasoning salts were bought in the local markets in Ile-Ife. The *Amaranthus* vegetable was blanched as previously described (Adewusi *et al*., 1999; Adewusi and Falade, 1996). *Corchorus olitorius* leaves were separated from the stalk, washed with distilled water, drained of water and kept in the freezer.

Analytical technique:
Moisture content: Moisture content was determined by (AOAC, 1990) method.

Phytate: Phytate was determined by the Anion-Exchange methods of Harland and Oberleas (1986).

Tannin: Tannin was quantified by the modified Vanillin-Hydrochloric acid method (Price *et al.,* 1978).

Determination of total and available mineral content: Total mineral content was determined from 4 g of each vegetable sample and 0.5 g of the cowpea weighed in triplicate. 10 ml conc. HNO_3 was added to each sample in a digestion flask and allowed to stand overnight. The samples were heated carefully until the production of brown nitrogen (iv) oxide fume has ceased. The flasks were cooled and (2 - 4 ml) of 70% perchloric acid was added. Heating was continued until the solutions turned colorless. The solutions were transferred into 50 ml standard flasks and diluted to mark with distilled water. Total mineral content was then analyzed by ALPHA 4 Atomic absorption spectrophotometer.
Available mineral content was determined by method of Miller *et al.* (1981) with some modifications.

Preparation of test meals: The wet weight of the equivalent of 6 g dry sample of *Amaranthus* was mixed with water homogenized in a Kenwood KW 10 food blender to a creamy consistency. The meal was adjusted to a pH of 2 with 6 M HCl and more water was added to give a 300 g meal, which was divided into three equal portions and kept in the freezer until used.

***Corchorus* sample:** The wet weight of the equivalent of 6 g dry sample of the vegetable leaves was mixed with water, boiled for 20 minutes as done locally. The product was then cooled, water was added and blended to a creamy consistency. The meal was adjusted to a pH of 2 with 6 M HCl and more water was added to give a 300 g meal, which was kept in three equal lots in the freezer until needed.

Condiments and seasoning salts: One gram dry weight of each sample was separately mixed with water, blended where necessary to a creamy consistency, adjusted to pH 2 and more water was added to make 100 g meal stored in a freezer until needed.

Simulated digestion of test meals:
Pepsin-HCl digestion: The frozen meal from (I) above was thawed at 37°C and divided into 25 g aliquots. Pepsin digestion was continued as previously described (Adewusi *et al*., 1999).

Pancreatin digestion: The frozen 25 g pepsin digest from (b) above was thawed and placed into a 100 ml beaker. Dialysis tubing (12,400 molecular weight cut off obtained from Sigma) which contained 10 ml distilled water and an amount of $NaHCO_3$ equivalent to the measured titratable acidity was placed into the beaker containing 25 g pepsin digest sample. The beaker was sealed with parafilm and incubated in a Buchi water bath model No 887196, type B 465 at 37°C with continuous agitation until pH was about 5 (approx. 30 min). Pancreatin-bile extract mixture (6.25 ml) was then added to the beaker and incubated for 2 h with gentle shaking. The volume of the dialysate was noted and then frozen until used.

Preparation of composite test meals: One gram of each seasoning salt or its equivalent wet weight of the condiments was separately mixed with 5 g (dry weight) of each vegetable. Water was added to the mixture blended to a creamy consistency and then more water was added to make a 300 g meal. The resulting mixture was treated as in (a) and (b) above.
Determination of titratable acidity was carried out as described by Miller *et al*., (1981).

Estimation of available mineral: Protein from the dialysate was precipitated as previously described (Adewusi *et al*., 1999) and the supernatant was diluted as required for available mineral determination using ALPHA 4 Atomic Absorption Spectrophotometer.

Statistical analysis of data: The results were expressed as a mean of three determinations with the exception of tannin, phytate and dietary fiber and available minerals that were presented as the mean of four determinations ± SD.

Results and Discussion

Total and available iron content: The total iron content presented in Table 1 ranged between 75 mg/kg for *Amaranthus* and *Corchorus* vegetables and 115 mg/kg for African locust bean. The iron content of both seasoning salts (*Maggi* and A-one) was higher than that in the vegetables and could therefore be considered as a supplementary source of this important mineral if used in large quantities. Unfortunately, these seasoning salts can only be used sparingly otherwise the soup becomes too salty. The iron content of the African locust bean seed decreased with processing such that the final product (*iru*) contained 20% less total iron than the staring material. On the other hand, there was no change in the total iron content of melon seed with processing to give *ogiri*. The total iron content of *Amaranthus* was similar to the value quoted earlier (Falade *et al.*, 2003) though these values were lower than that obtained in our laboratory for a similar sample (Adewusi *et al.*, 1999) and values reported for 46 lines of from 12 species of *Amaranthus* (Rangarajan and Kelly, 1998). The lower value recorded for *Amaranthus* species in this study is probably a reflection of the soil/ location and other environmental factors of the site in which these samples were grown. For instance, the total iron content of *Amaranthus* species grown in the field ranged between 358 and 880 mg/kg dry weight but when the same *Amaranthus* species were grown in the glasshouse the total iron content decreased by as much as 90% to between 55 and 123 mg/kg (Rangarajan and Kelly, 1998). The availability of iron was highest from *Maggi* seasoning salt (35%) and lowest in melon seed and *Amaranthus* vegetable (21%). These values indicated a high availability of iron compared to such plant products as legumes with iron availability as low as 3% (Adewusi and Falade, 1996). The percentage availability of iron from *Amaranthus* in this study was higher than the 12% reported earlier (Adewusi and Falade, 1996; Adewusi *et al.*, 1999). The percent iron availability of *Amaranthus* also varied from species to species thus the availability was 43 ± 5% in the greenhouse samples and 6-12% in field grown samples (Rangarajan and Kelly, 1998; Rangarajan *et al.*, 1998).

The Effect of seasoning salts and condiments on iron availability: Despite the high percentage of iron availability from all the samples investigated; there was a reduction in the available iron content of *Corchorus* - seasoning salt or condiment composite diets. All the additives (seasoning salts and the condiments) to the vegetables decreased iron availability by about 40% except A-one, a 99.9% monosodium glutamate salt, which inhibited iron availability by only 10%. Processing African locust bean and melon seed to the condiments did not seem to affect the level of inhibition of iron availability in *Corchorus* based diets by these additives. The results in Table 2 indicated the presence of a high level of phytate in *Corchorus* vegetable. Tannin and phytate were also present in both African locust bean and melon seed. These antinutritional factors plus the dietary fibre present in the vegetable products (Fernandez and Phillips, 1982) have been established to inhibit iron availability (Hurrell *et al.*, 1999) and these could have acted synergistically to decrease the iron availability in the composite food products.

In *Amaranthus* vegetable, *Maggi* seasoning salt, *iru* and *ogiri* increased iron availability in the composite diets by about 40% while the starting materials for the condiments - African locust bean and melon seeds as well as the A-one seasoning salt had a low but negative effect on iron availability from this vegetable (Table 1). Blanching *Amaranthus* vegetable reduced the tannin content to a level slightly lower than that found in *Corchorus* while the phytate content in the blanched *Amaranthus* was 300% lower than that found in the *Corchorus* vegetable sample (Table 2). This factor may explain in part the difference in the result observed between the composite diets of *Corchorus* and *Amaranthus* vegetables in terms of iron availability. Processing African locust bean to iru decreased the phytate content by 50% but seem to increase tannin 3-fold. Despite this fact, *iru* increased the available iron content from *Amaranthus* vegetable by 34% while locust bean reduced iron availability by 10%. This is not surprising since fermentation of locust bean to iru resulted in protein hydrolysis to yield peptides and amino acids (Omafuvbe *et al.*, 2000, 2002, 2003), some of which have been known to enhance iron availability (Reinhold *et al.*, 1981). Processing melon seed to *ogiri* resulted in about 250% decrease in the tannin content while the phytate content seem unaffected (Table 2). Since fermentation of melon seed also yielded amino acids and peptides, this could also account for the 46% increase in the available iron content of its composite diet with *Amaranthus* vegetable.

Total and available magnesium content: The total content of magnesium was lowest in A-one seasoning salt which is 99.9% monosodium glutamate. *Maggi* cube was better with 107 mg/kg dry weight (Table 3). The plant foods and products contained a higher level of magnesium ranging from 1370 for *iru* to 3700 mg/kg dry sample *Amaranthus* vegetable. Fermentation of African locust bean to yield the product (*iru*) decreased the total magnesium content by 50% while fermentation increased the total magnesium from 1945 in melon seed to 2202 mg/kg dry weight in *ogiri*. The total magnesium content of blanched *Amaranthus* was about 50% lower and 100% higher than the values quoted for two similar samples from this laboratory (Adewusi *et al.*, 1999; Falade *et al.*, 2003).

Table 1: Total and Percent Available Iron Content of Some Seasoning salts, African Locust Bean, Melon Seed and the Condiments - *Iru* and *Ogiri* together with the Theoretical and Experimental Available Iron of the Composite Diets[1]

Sample	Total Iron mg/kg	% Available Iron	Available Iron (mg / kg) in Seasoning salt / Condiment - Vegetable Composite Diets					
			Seasoning salt / Condiment + *Corchorus*[2]			Seasoning salt / Condiment +*Amaranthus*[3]		
			Theoretical	Experimental	% Df[4]	Theoretical	Experimental	% Df[4]
Maggi*	93 ± 14	35	22 ± 1.4	14 ± 1.1	-38	16 ± 0.8	22.5 ± 0.7	+41
A-One**	84 ± 2	25	23 ± 1.4	21 ± 1.4	-10	17 ± 1.7	15.5 ± 0.3	- 8
Locust bean	115 ± 20	25	24.3 ± 0.8	14.5 ± 0.9	-40	18 ± 1.0	16.2 ± 0.4	- 0
Iru	93 ± 2	24	23 ± 1.2	16.8 ± 4.3	-28	17 ± 1.3	23 ± 1.9	+34
Melon seed	98 ± 10	21	24 ± 6.1	14 ± 1.1	-43	18 ± 0.7	16.2 ± 0.6	- 0
Ogiri	95 ± 5	28	23 ± 1.1	12.8 ± 0.8	-44	17 ± 1.8	24 ± 1.4	+46
Corchorus	75 ± 3	31	-	-	-	-	-	-
Amaranthus	75 ± 9	21	-	-	-	-	-	-

[1]Mean ± standard deviation of quadruplicate analysis. [2]Composite diet = fruit juice and Amaranthus mixed in ration 4:1
[3]Composite diet = fruit juice and cowpea mixed in ratio 9:1 [4]Df = difference between theoretical and experimental values.
*Maggi cube is a commercial beef broth flavoured seasoning salt. ** A-one is a 99.9 % monosodium glutamate commercial product.

Table 2: The Moisture, Phytate and Tannin Content of Some Seasoning salts, African Locust Bean, Melon Seed and the Condiments - *Iru* and *Ogiri*

Sample	Moisture %	Phytate (mg/100 g DW)	Tannin[a] (mg/g catechin equivalent)
African locust bean	9.0 ± 0.6	51 ± 2.2	3.5 ± 0.00
Iru[b]	52.0 ± 0.6	25.0 ± 0.0	9.8 ± 1.8
Melon seed	10.3 ± 0.2	10.0 ± 0.0	6.5 ± 0.00
Ogiri[c]	51.7 ± 0.7	10.0 ± 0.1	2.5 ± 0.7
Maggi*	3.8 ± 0.1	9.4 ± 0.00	3.8 ± 0.7
A-One**	0.6 ± 0.02	ND	ND
Corchorus	92.5 ± 0.2	559 ± 53	9.8 ± 0.4
Amaranthus (Raw)	81 ± 1.1	235 ± 27	16 ± 1.0
Amaranthus (blanched)	89 ± 1.7	194 ± 17	9 ± 2.1

[a] - tannin content of samples are expressed on a dry weight basis, [b] - Processed African locust bean, [c]- Processed melon seeds, * Maggi cube is a commercial beef broth flavoured seasoning salt. ** A-one is a 99.9% monosodium glutamate commercial product. ND - not determined

Percent available magnesium ranged from 13% in melon seed to 42-43% in the seasoning salts (Table 3). The available magnesium from blanched *Amaranthus* (25%) in this study was lower than the 40.4% and higher than the 18% reported for blanched *Amaranthus* samples in earlier studies (Adewusi *et al.*, 1999; Falade *et al.*, 2003). Fermentation of the African locust bean to the product (*iru*) did not seem to affect magnesium availability while fermentation increased magnesium availability from 13% in melon seed to 21% in the product - *ogiri*. The level of magnesium was higher in the blanched *Amaranthus* and with better availability this vegetable should be a better source of magnesium compared to *Corchorus* vegetable (Table 3).

Composite meals: The seasoning salts produced the highest enhancement of magnesium availability in *Corchorus* vegetable while African locust bean and melon seeds inhibited magnesium availability by 23 and 54% respectively.

Table 3: Total and Percent Available Magnesium Content of Some Seasoning salts, African Locust Bean, Melon Seed and the Condiments - *Iru* and *Ogiri* together with the Theoretical and Experimental Available Magnesium of the Composite Diets[1]

Sample	Total Magnesium mg/kg	% available Magnesium	Available Magnesium (mg/ kg) in Seasoning salt/Condiment-Vegetable Composites Diets					
			Seasoning salt / Condiment +*Corchorus*[2]			Seasoning salt/Condiment+*Amaranthus*[3]		
			Theoretical	Exptal	Df[4]	Theoretical	Exptal	% Df[4]
Maggi*	107±2.5	43	408±6	505±14	+24	785±4	665±10	-15
A-One**	25±2	42	401±6	455±9	+14	778±4	824±18	+6
Locust bean	2700±93	23	504±8	390±11	-23	881±3	781±4	-11
Iru	1370±141	22	451± 6	473±27	+4.9	828±3	826±33	-0.2
Melon seed	1945±81	13	442±5	202±1	-54	819±4	791±5	-3.4
Ogiri	2202±125	21	479±6	412±13	-14	856±5	768±17	-10
Corchorus	3259±47	15	-	-	-	-	-	-
Amaranthus	3700±321	25	-	-	-	-	-	-

[1]Mean ± standard deviation of quadruplicate analysis. [2]Composite diet = fruit juice and Amaranthus mixed in ration 4:1.
[3]Composite diet = fruit juice and cowpea mixed in ratio 9:1. [4]Df = difference between theoretical and experimental values.
*Maggi cube is a commercial beef broth flavoured seasoning salt. **A-one is a 99.9 % monosodium glutamate commercial product.

Table 4: Total and Percent Available Copper Content of Some Seasoning salts, African Locust Bean, Melon Seed and the Condiments - *Iru* and *Ogiri* together with the Theoretical and Experimental Available Copper of the Composite Diets[1]

Sample	Total Copper mg/kg	% Available Copper	Available Copper (mg/ kg) in Seasoning salt/Condiment-Vegetable Composite Diets					
			Seasoning salt/Condiment *Corchorus*[2]			Seasoning salt/Condiment ++ *Amaranthus*[3]		
			Theoretical	Exptal	Df [4]	Theoretical	Exptal	% Df[4]
Maggi*	5.2±0	30.2	2.0±0.1	1.3±0.1	-36.2	1.7±0.3	1.3±0.1	-24
A-One**	5.0±0	38.8	2.0±0.1	1.2±0.2	-39.1	1.7±0.2	1.2±0.1	-29
Locust bean	18±1.8	10.5	2.0±0.2	1.3±0.2	-35.3	1.7±0.2	1.3±0.1	-24
Iru	36±6.0	6.6	2.1±0.1	1.0±0.1	-50.2	1.8±0.2	1.6±0.1	-11
Melon seed	31±6.0	5.9	2.0±0.15	1.5±0.1	-26.0	1.7±0.2	1.9±0.3	+9
Ogiri	19±2.6	9.7	2.0±0.01	1.5±0.2	-29.9	1.7±0.1	1.2±0.1	-29
Corchorus	20±1.0	10.1	-	-	-	-	-	-
Amaranthus	20±2 .2	8.1	-	-	-	-	-	-

[1]Mean ± standard deviation of quadruplicate analysis. [2]Composite diet = fruit juice and Amaranthus mixed in ration 4:1.
[3]Composite diet = fruit juice and cowpea mixed in ratio 9:1. [4]Df = difference between theoretical and experimental values.
*Maggi cube is a commercial beef broth flavoured seasoning salt. **A-one is a 99.9% monosodium glutamate commercial product.

Table 5: Total and Percent Available Zinc Content of Some Seasoning salts, African Locust Bean, Melon Seed and the Condiments - *Iru* and *Ogiri* together with the Theoretical and Experimental Available Zinc of the Composite Diets[1]

Sample	Total Zinc mg/kg	% available Zinc	Available Zinc (mg / kg) in Seasoning salt / Condiment - Vegetable Composite Diets					
			Seasoning salt/Condiment + *Corchorus*[2]			Seasoning salt / Condiment +*Amaranthus*[3]		
			Theoretical	Exptal	%Df[4]	Theoretical	Exptal	%Df[4]
Maggi*	26.0± 00	32	6.4± 0.7	6.3±0.5	-2	7.9±0.6	6.6±0.4	-17
A-One**	27±1.2	15	5.7±0.9	6.9±0.6	+21	7.2±0.6	7.4±0.5	+25
Locust bean	42.7±2.0	17	6.2±1.1	3.8±0.1	-39	7.7±0.7	9.0±0.6	+11
Iru	86.1±2.6	7	6.0±0.8	5.7±0.7	-5	7.5±1.3	8.6±0.3	+15
Melon seed	58.1±0.3	7	5.7±0.6	3.7±0.7	-35	7.2±1.1	10.4±1.6	+45
Ogiri	70.4±2.1	17	7.0±1.1	4.8±0.3	-32	8.5±0.7	8.6± 0.6	+2
Corchorus	14.1±1.4	42	-	-	-	-	-	-
Amaranthus	24.5±1.7	31	-	-	-	-	-	-

[1]Mean ± standard deviation of quadruplicate analysis. [2]Composite diet = fruit juice and Amaranthus mixed in ration 4:1.
[3]Composite diet = fruit juice and cowpea mixed in ratio 9:1. [4]Df = difference between theoretical and experimental values.
*Maggi cube is a commercial beef broth flavoured seasoning salt. **A-one is a 99.9% monosodium glutamate commercial product.

Fermentation of both starting materials resulted in improved magnesium availability with *iru-Corchorus* vegetable composite diet having a slight enhancement in magnesium availability while the inhibition in *ogiri-Corchorus* composite was not as severe (Table 3). In *Amaranthus* composite diets, only the A-one seasoning salt yielded a slight enhancement (6%) of magnesium availability; *iru* and melon seed had no appreciable effect on magnesium availability while *ogiri* and *Maggi* inhibited magnesium availability by 10-15%.

Total and available copper content: The copper content of locust bean in this study (Table 4) was in close agreement with the 15 mg / kg value reported by Eka (1980). *Amaranthus* and *Corchorus* vegetables contained the same level of copper (20 mg/kg); lower than the 25 mg/kg in groundnut reported by Oyenuga (1968) but higher than the 16 mg/kg reported for green beans by Martinez *et al.* (1998) and the 17 mg/kg value observed for a sample of cowpea (Falade, unpublished results). A-one and *Maggi* contained the same low level of copper around 5 mg/kg sample (Table 4). Percent available copper was high in both seasoning salts (>30%) and low in all the other plant foods especially melon seed with 5.9% availability. The total copper content of the locust bean was doubled by fermentation from 18 to 36 mg/kg while that of melon seed (31 mg/kg) was reduced by 39%. In contrast, fermentation reduced copper availability in locust bean by 37% but increased that of melon seed by 64% in the product - *ogiri*.

Composite diets: Both seasoning salts, condiments and starting materials reduced the availability of copper in *Amaranthus* composite diets except melon seed in which there was a slight increase of 9%. All the additives impaired copper availability from the *Corchorus* composite diets by 26-50%. Ascorbic acid has been reported to inhibit copper availability through the reduction of copper (II) to copper (I) and its subsequent precipitation (Van den Berg *et al.*, 1994). In addition to this possibility is the pH of the additives which ranged between 6.2 (African locust bean) and 8.4 for iru (Omafuvbe *et al.*, 2003). This pH range has been known to enhance the binding of divalent metal ions to fibres (Clydesdale and Camire, 1983) as well as aid the reduction of di- to mono-valent ions thus ensuring their precipitation. *Corchorus* vegetable is mucilaginous and is often referred to as “draw soup” which ensures the presence of a good amount of soluble fibre which can bind metallic ions reducing their availability.

Total and available zinc content: Total zinc content was lowest in *Corchorus* and highest in *iru* as presented in Table 5. *Amaranthus* vegetable used in the present study had 50% of the zinc content (50 mg/kg) of another *Amaranthus* sample reported from this laboratory in 2003 (Falade *et al.*, 2003) but agreed closely with 24 mg / kg also reported earlier (Adewusi and Falade, 1996; Adewusi *et al.*, 1999). The zinc content of *Maggi* (26 mg/kg) was similar to that contained in A-one (27 mg/ kg) and that of *Amaranthus* vegetable indicating that these seasoning salts could provide zinc in the meal if it is bioavailable. Fermentation of African locust bean increased the zinc content by 102% in the product - *iru* and that of melon seed by 21% in *ogiri*. This could make the condiments a veritable source of zinc as they are liberally used in poor homes in lieu of meat and its products.

Percent available zinc was high in *Corchorus* (42%), followed by *Amaranthus* and *Maggi* (31-32%) and the least from *iru* (Table 5). The availability of zinc from *Amaranthus* in the present study was within the 21 and 42% availability reported earlier from our laboratory (Adewusi and Falade, 1996; Adewusi *et al*., 1999, Falade *et al*., 2003). The percent available zinc was increased 7% in melon seed to 17% in its condiment product (*ogiri*) while the reverse was the case in locust bean with availability being reduced from 17 to 7%. The only big difference between iru and ogiri is the phytate content which is about 300% more in iru compared to ogiri (Table 5) and this coupled with the high pH in *iru* (Omafuvbe *et al*., 2003) may therefore account for the inhibition observed.

Composite meals: Despite the individual high percentage of zinc availability from *Amaranthus* and *Maggi* seasoning salt, zinc availability was inhibited by 17% when both samples were combined in a composite diet compared to a no effect phenomenon in *ogiri-Amaranthus* composite diet and as much as 45% enhancement in zinc availability in melon seed-*Amaranthus* composite diet. As observed earlier, the percent zinc availability from melon seed was significantly lower than that of *ogiri* (Table 5), this reversed trend in the availability in melon seed-and *ogiri-Amaranthus* composite diets cannot be easily explained. In the same vein, *Corchorus* vegetable which had the highest percentage availability of zinc failed to enhance zinc availability in any composite diet. Indeed, percent zinc availability was reduced in all the *Corchorus* composite diets with African locust bean, melon seed and *ogiri* recording negative values above 30%. Interestingly, fruit juices other than lime inhibited zinc availability from cowpea while enhancing zinc availability by 12-38% in *Amaranthus* composite diets (Falade *et al*., 2003). The inhibition was ascribed to the higher level of anti-nutritional factors present in cowpea (Adewusi and Falade, 1996; Falade *et al*., 2003). The inhibition of mineral availability could also be explained if the added ligand increases the level of anti-nutrients that bind minerals.

Conclusion: Fermentation seems to enhance mineral availability in both *Amaranthus* and *Corchorus* vegetables though this is more prominent in the former vegetable than the latter. Even where the percentage difference was negative, fermentation reduced the inhibition observed in the starting materials to manageable proportions. The higher crude protein content (Omafuvbe *et al*., 2004) seems to make *iru* a better nutritional additive than *ogiri*. Fortunately, *iru* (*daddawa*) seems to be consumed more than *ogiri* in Nigeria.

There seems to be no significant difference between the effect of the synthetic seasoning salts and those of the local condiments on mineral availability. The FDA has been quoted as pronouncing monosodium glutamate as safe for consumption at the traditional level of usage but the controversy surrounding the health implication of monosodium glutamate consumption (Lee, 2003) makes it prudent to call for the promotion of the traditional condiments over the synthetic monosodium glutamate.

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