EFFECT OF PROCESSING ON THE MINERAL ELEMENTS AND ANTI-NUTRIENTS OF SOME EDIBLE VEGETABLES FROM KEFFI, NASARAWA STATE, NIGERIA

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Abstract: This study investigated the effect of boiling, steaming and sun drying on the mineral elements and anti-nutrients of six varieties of edible vegetables: Ewedu *(Corchorus olitorius)*, water leaf (*Talinum triangulare)*, sand sagebrush (*Arternesia spp*), pumpkin leaf (*Telfairia occidentalis*), bitter leaf (*Vernonia amygdalina*) and spinach (*Spinacia oleracea*). The mineral elements and anti-nutrients were determined using standard analytical methods. Sodium, zinc, copper, magnesium, phosphorus and iron were among minerals present with phosphorus as the most dominant of these minerals obtained with values ranging from 31.31 mg/100 g in boiled water leaf to 225.90 mg/100 g in sundried pumpkin leaf. Anti-nutrients such as saponin was obtained with values ranging from 2.14 – 3.06% (in water leaf), 0.72 – 2.82% (in ewedu), 2.18 – 2.72% (in sand sagebrush), 2.10 – 2.68% (in spinach), 0.12 – 2.15% (in bitter leaf) and 0.08 - 0.20% (in pumpkin leaf). Processing methods showed deviation in minerals of 235.00% (phosphorus) in boiled water leaf to 0.09% in sun dried pumpkin leaf and anti-nutrients from the raw leaves. The deviation was observed more on anti-nutrients like oxalate, phytate, alkaloids and cyanide. For minerals, the deviation was more on the amount of phosphorus and magnesium after boiling and steaming. Sun drying was insignificant. Processing reduces the mineral content of the vegetables, but makes them bioavailable by removing the anti-nutrients to the barest minimum.

Keywords: Anti-nutrients, minerals, processing, edible, vegetables

Introduction

Leafy vegetables are important part of diet in many Nigerian homes as they add varieties to the menu. Edible leaves from vegetables plants are eaten as supporting food or main dishes (Hanif *et al*., 2006). Most of the vegetables in abundance shortly after rainy season become scarce during the dry season. They are the cheapest and the most accessible source of proteins, vitamins, minerals, fibre and essential amino acids (Okafor, 1983; Fasuiji, 2006).

More importantly, leafy vegetables are highly beneficial for maintenance of health and prevention of diseases. The world health organization and the food and agricultural organization of the united nations advocates a minimum intake of 400 g of fruits and vegetables per day for adults to prevent chronic diseases like cancer, heart ailments, diabetes and micro nutrients deficiencies. It recommends that people should eat at least five varieties of fruits and vegetables every day. Supporting this point, Hanif *et al*. (2006) related that vegetables contain valuable sources of food ingredients that can be utilized to build up and improve the body successfully. They also maintain alkaline reserve of the human body. There are different types of vegetables and each group constitutes in its own way to the diet (Robinson, 1990). Hence, they play prominent roles in the traditional food of many cultural groups. Various ethnic groups consume variety of different indigenous types of vegetables for different reasons as some considered them to be medicinal and blood tonic. As stated by Mensah *et al*. (2008), addition of a small amount of vegetables like spinach and water leaf in food intake can prevent the occurrence of diseases such as river blindness.

In Nigeria, leafy vegetables are frequently processed in order to make them edible. In addition, they are processed to prevent them from spoilage by both traditional and modern methods. Some predominant methods include but not limited to the following; sun-drying, air-drying, blanching, steaming, boiling, reheat and freezing.

Green leafy vegetables despite their nutritional value are to be consumed with caution because of the presence in them toxic anti-nutrients (Everist, 1981). Anti-nutrients are natural compounds that interfere with the absorption of nutrients availability to animals and humans (Hanif *et al*., 2000). The higher the concentrations, the greater the risk posed on consumption. Adeboye and Babajide (2007) reported that the presence of anti-nutrients components in green leafy vegetables prevent efficient utilization of Calcium, Zinc, Iron, and Copper by the formation of insoluble complexes with the minerals elements. Common anti-nutrients found in vegetables includes: Tannin, Hydrocyanic acid (HCN), saponins, oxalates, phytates and polyphenols (Mensah, 2008).

These anti-nutrients are usually present in trace amount and are found at different levels in almost all foods. The level in food crops however, get reduced by in-home preparations and storage techniques (Adetuyi *et al*., 2008; Anderson, 2005). According to Anderson (2005), anti-nutrients can easily be detoxified by various processing method such as soaking, boiling, and frying. Processing partly removes anti-nutrients and lower food toxicity. However, consumption of large quantities of such food may still result in a health risk.

This study is designed to determine the effect of processing on the minerals and anti-nutrients of six edible vegetables (spinach, ewedu, pumpkin leaf, water leaf, bitter leaf and Sand sagebrush in Keffi, Nasarawa state, Nigeria.

Materials and Methods

Sample collection

The six edible vegetables, ewedu (*Corchorus olitorius*), water leaf (*Talinum triangulare*), sand sagebrush (*Arternesia spp*), pumpkin leaf (*Telferia occidentals*), bitter leaf (*Vernonia amygalsdina*), spinach (*Spinacia oleracea*) were purchased from some local farmers in Keffi market in Nasarawa state, Nigeria.

Sample preparation

Raw

A quantity of 100 g each of the six vegetable samples were washed in a running tap and dried at room temperature on a clean tray for eight days (Emmanuel *et al*., 2011). During the process, the vegetables were turned occasionally until they were properly dried. The leaves were later ground into powder using an electric blender, sieved using a 1 mm sieve and kept in an air-tight container for analyses.

Boiling

100 g each of the different vegetable already washed was cooked in already boiled water for three minutes. 50 ml of Cold water was added to stop the boiling process (Emmanuel *et al*., 2011). The vegetables were drained using a drainer cooled and oven dried at a temperature of 115°C. Then ground, sieved using a 1 mm sieve and the powdered sample stored in an air-tight container for analyses.

Steaming

100 g of the variety of the vegetables were rinsed thoroughly with portable water. Then water was allowed to drain out of the vegetable. Sample was placed over the boiling water to steam through the hot vapour (steam) for three minutes. Cooled water was added stop the steaming process (Emmanuel *et al*., 2011). The samples were cooled, dried in an oven, then ground, sieved and the powdered samples kept in a clean container ready for analyses.

Sun drying

The 100 g of the washed vegetables were sun dried for five hours daily for six days (Emmanuel *et al*., 2011). Samples turned occasionally until they were properly dried. Then samples were ground and sieved into fine powder. The powdered samples were kept in air-tight containers.

Mineral content determination

Na and K analysis of the samples were done by flame photometry method. Zinc, Iron, Magnesium, Phosphorus and Copper contents were analyzed using computer controlled AAS solar. 1969.

Anti-nutrients determination

Oxalate, saponins, cyanide and flavonoid were determined using standard techniques (AOAC, 1980). While phytate was by the method of Reddy *et al*. (1982) and alkaloids by the method of Hudson and El-difraw (1979).

Results and Discussion

The mineral contents of the raw and processed samples of the six vegetables, spinach (*Amaranthus aquatica*), ewedu (*Corchorus olitorius*), water leaf (*Talinum triangulare*), pumpkin leaf (*Telfairia occidentalis*), bitter leaf (*Vernonia amygdalina*) and sand sagebrush (*Anternesia* spp) are presented in Table 1. The most abundant mineral in the raw and processed samples of the six vegetables was phosphorus (139 – 226.10 mg/100g) in raw, (35.90 mg/100—81.09 g/100g) steamed, (37.00 mg/100g – 98.99 mg/100g) boiled and (111.50 mg/100g – 218.00 g/100g) sundried followed by magnesium (22.04 – 116.00 mg/100g) in raw, (49.00 – 100.10 mg/100g) steamed, (37.00-98.99 mg/100g) in boiled and (112.60-218.00 mg/100g) sundried.

The least concentrated mineral was zinc (0.30 – 1.80 mg/100g). These values are extremely higher than values reported for *A. aquatia* 0.67 mg/100 g and T. *occidentalis* (1.25 mg/100 g) (Oguche & Gladys, 2011). This could be as a result of the soil type in which they are grown because major mineral composition of vegetables varies widely depending on the condition of soil (Adame, 2000). Magnesium is an essential mineral for enzyme activity like calcium and chloride; magnesium plays a role in regulating the acid alkaline balance in the body (Fallon and Enig, 2001). It also plays a significant role in photosynthesis, carbohydrate metabolism, nucleic acids and binding agent of cell walls (Russel, 1973). Phosphorus assists calcium in many body reactions, although it also has independent functions. Modern diets that are rich in animal proteins and phosphorus may promote the loss of calcium in the urine (Shills and Young, 1992).

The values (mg/100 g) of other minerals in the raw samples were iron (3.14-8.28), sodium (2.00-46.55) and copper (0.41-3.64).

Table 1: Results of mineral contents (mg/100 g) of six varieties vegetable

Parameter	SP	EW	WL	PL	BL	SS
			Raw			
Zn	0.60	0.30	0.50	1.39	1.81	0.40
Na	39.00	20.00	2.00	46.55	42.06	20.00
Cu	0.13	0.41	0.60	3.64	1.06	0.60
Mg	113.00	114.00	112.00	22.04	116.00	116.00
P	139.10	210.00	180.00	226.10	190.20	180.00
Fe	3.14	4.60	8.28	4.50	3.43	4.02
			Steaming			
Zn	34	0.18	0.39	0.22	0.04	0.28
Na	2.01	4.00	7.99	12.90	11.90	6.10
Cu	06	0.14	0.39	2.80	0.10	0.40
Mg	49.00	60.00	59.10	100.10	50.43	63.80
P	52.00	40.00	35.90	61.09	81.09	38.10
Fe	3.14	2.43	4.71	2.01	2.00	2.00
			Boiling			
Zn	0.20	0.02	0.20	0.17	0.01	0.21
Na	11.43	2.83	6.70	12.00	10.54	5.89
Cu	0.24	0.01	0.25	2.76	0.08	0.32
Mg	48.10	37.00	50.50	98.99	50.23	60.30
P	60.02	38.28	31.31	60.72	81.02	13.00
Fe	1.32	1.90	3.32	1.97	1.02	1.69
			Sun drying			
Zn	0.54	0.25	0.43	1.28	1.76	0.36
Na	38.30	19.50	21.63	46.51	41.20	18.50
Cu	0.10	0.40	0.57	3.58	1.01	0.58
Mg	112.60	113.6	11.50	218.00	158.90	11.20
P	138.00	207.4	176.20	225.90	191.20	179.00
Fe	2.90	4.02	7.69	4.02	3.87	3.87

SP = spinach, EW = ewedu, WL = water leaf, PL = pumpkin leaf, BL = bitter leaf, SS = sand sagebrush

Table 2: Difference in mineral composition between raw and processed vegetables

Parameters	SP	EW	WL	PL	BL	SS
			Steaming			
Zn mg/100g	0.3	0.12	0.14	1.17	1.77	0.12
	50.00%	40.00%	28.00%	84.17%	0.98%	30.00%
Na mg/100g	26.99	16.00	5.99	33.65	30.16	13.9
	69.21%	80.00%	299.50%	72.29	71.71%	69.5%
Cu mg/100g	0.07	0.27	0.21	0.84	0.96	0.20
	53.85%	65.83%	35.00%	23.08	90.57%	33.33%
Mg/mg/100g	77.10	54.00	52.9	-77.96	65.57	52.2
	55.43%	47.37%	47.23%	-353.72%	56.53%	45.00%
P mg/100g	77.0055.	70.00	144.10	-77.96	111.11	141.9
	40%	80.95%	80.06%		57.81%	78.83%
Fe mg/100g	0.00	2.17	3.57	2.49	2.29	2.02
	0.00%	47.17%	53.33%	55.33%	66.76%	50.25%
			Boiling			
Zn mg/100g	0.40	0.28	0.30	1.22	1.50	0.21
	66.67%	93.33%	60.00%	87.77%	99.45%	52.50
Na mg/100g	27.57	17.17	-4.70	34.55	31.52	14.11
	70.69%	85.85%	-235.00%	74.22%	74.94%	70.55%
Cu mg/100g	-0.07	0.40	0.35	0.88	0.898	0.28
	-5.39%	97.56%	58.33%	24.18%	95.45%	46.67%
Mg/mg/100g	64.9	77.00	61.50	-76.95	65.77	55.7
	57.43%	67.64%	54.91%	-349.14%	56.70%	48.02%
P mg/100g	79.08	171.72	148.69	165.38	11.18	144.00
	81.79%	81.79%	82.61%	73.15%	57.85%	80.00%
Fe mg/100g	2.70	2.70	4.96	2.53	2.41	2.33
	58.70%	58.70%	59.90%	56.22%	70.26%	57.96%
			Sun drying			
Zn mg/100g	0.06	0.05	0.07	0.11	0.05	0.04
	10.00%	16.67%	14.00	7.91%	2.76%	10.00%
Na mg/100g	0.70	0.50	-19.63	0.04	0.86	11.5
	1.80%	2.50%	-981.5%	0.09%	2.05%	57.5%
Cu mg/100g	0.03	0.01	0.03	0.06	0.05	0.02
	23.08%	2.44%	5.00%	1.65%	4.72%	3.33%
Mg/mg/100g	0.40	0.40	0.50	-195.96	42.90	1.80
	0.35%	0.35%	0.45%	-889.11%	36.98%	1.55
P mg/100g	1.10	2.60	3.80	0.20	1.00	1.00
	0.79%	1.24%	22.11%	0.08%	0.52%	0.56%
Fe mg/100g	0.24	0.58	0.39	1.61	0.54	0.15
	7.64%	12.61%	47.1%	35.78	15.74%	3.73%

SP = spinach, EW = ewedu, WL = water leaf, PL = pumpkin leaf, BL = bitter leaf, SS = sand sagebrush

From Table 2, it shows that mineral content of all the processed vegetables (steamed, boiled and sundried) were reduced. The rate of reduction was such that steaming had higher rate of reduction followed by boiling while sun drying had the least. The present observation agreed with those of many workers (Udofia and Obizoba, 2005). Drying is known to reduce moisture to improve the shelf life of foods and increase dry matter. Wachap (2005) reported similar observation in many dried vegetables consumed in Taraba State Nigeria. Sun drying generally does not have significant effect on mineral contents. For boiling, the decrease must have been as a result of leading and metabolic activities. This is similar to the result obtained by Bolanle *et al*. (2004) who observed a decrease in mineral contents of vegetables after boiling and steaming.

The processing methods reduced phosphorus content in all the six vegetables. The reduction was more on steaming and boiling (62.00, 40.00, 35.90, 61.09, 81.09 and 38.10) and (60.02, 38.28, 31.31, 60.72, 81.02 and 36.00) relative to the raw samples (139.10, 210.00, 180.00, 226.10, 192.20 and 180.00). On the other hand, the reduction was much lower on all the vegetables on sun drying (138.00, 207.4, 176.20, 225.90, 192.20 and 179.00). The magnesium content of the six raw samples were: 113.00 mg/100 g (spinach), 114.00 mg/100 g (ewedu), 112.00 mg/100 g (water leaf), 22.04 (pumpkin leaf), 116.00 g/100 g (bitter leaf and sand sagebrush). Processing caused a comparable reduction in magnesium in all vegetables except for pumpkin leaf where an increase was observed. The increase was by 355.72% in steaming while in sun drying an increase of 889.11% was obtained.

Sodium content of the six vegetables varied. Water leaf had the lowest value (2.00 mg/100 g), followed by ewedu leaf and sand sagebrush with equal values of (20.00 mg/100 g) then spinach (39.00 g), bitter leaf 42.06 mg/100 g, and pumpkin leaf (46.55 mg/100 g). Reduction on sodium content was more on the steaming and boiling method. No significant decrease was observed in the sun drying method when compared to the raw samples. An increase of 981.5% was observed as in the case of water leaf, the values ranged from 0.12 – 1.77/100 g (steaming), (0.21-1.22 g/100 g) in boiling. Copper, iron and zinc have lower amount in both the raw and processed samples. The value for copper ranged from 0.13 – 3.64 mg/100 g) in the raw sample, (0.06 – 2.80 g/100 g) in steaming, (0.01 – 2.76 mg/100 g) in boiling and (0.10 – 3.58 mg/100 g in sun drying. Iron and zinc in the raw samples ranged from (3.14 – 8.28 mg/100 g) and (0.30 to 1.80 mg/100 g). Processing caused significant decrease in iron and zinc. Same was observed for copper except for an increase 5.39% that was observed for spinach for boiling method.

Table 3 shows the anti-nutrient composition of the six different vegetables. The alkaloid content ranged from (1.46 – 2.87%) in the raw samples (0.80 – 2.13%) in the steamed, (0.62-2.12%) in the boiled and (1.46-2.8%) in the sundried samples. These values are lower than those for T. *triangulare* (55.56 ± 5.00 mg/100 g) and 13.89 ± 5.00 mg/100 g). Alkaloid has been used a CNS stimulate, topical anesthetic in ophthalmology, powerful pain relievers, anti puretic action, among other uses (Heikens *et al*., 1995).

The level of phytate in the vegetable samples ranged from (1.02 – 2.24%) in the raw sample, (0.46-1.92%) steamed, (0.44 – 1.91%) boiled and (0.99-2.22%). Saponins, oxalate, cyanide and flavonoids ranged from (0.20-3.06%) raw, (0.10-2.39%) steamed, (0.08-2.18%) boiled, (0.14-3.03%) sundried. Oxalate (1.25-2.35%) in raw, (0.85 – 1.83%) in steamed, (0.74-2.06%) in boiled and (1.20-2.16%) in sundried. Cyanide (0.24.0.43%) in raw, (0.16-0.29%) steamed, (0.11-0.72%) boiled and (0.21-0.42%) sundried. Lastly flavonoid concentration ranged from (1.48-2.62%) in raw, (1.19-3.15%) steamed, (1.20-3.00%) boiled and (1.46-3.96%) sundried.

Table 3: Results of anti-nutrient contents (%) of six varieties of vegetables

Parameters	SP	EW	WL	PL	BL	SS
			Raw			
Alkaloids	2.08	1.46	1.68	2.37	2.7	2.10
Phytate	1.09	1.26	1.4	1.59	2.24	1.02
Saponin	2.58	2.82	3.06	0.20	2.15	2.76
Oxalate	2.18	2.14	2.12	1.25	2.35	2.10
Cyanide	0.43	0.42	0.28	0.29	0.24	0.40
Flavonoid	1.48	2.62	2.40	1.76	3.98	1.94
			Steaming			
Alkaloids	1.38	1.42	0.88	1.80	2.13	1.46
Phytate	0.70	0.94	0.46	0.94	1.92	0.45
Saponin	3.39	1.72	0.10	0.10	0.13	1.24
Oxalate	1.76	1.66	1.64	0.88	1.83	1.14
Cyanide	0.69	0.28	0.16	0.17	0.13	0.22
Flavonoid	1.30	1.82	1.82	1.19	3.15	1.36
			Boiling			
Alkaloids	1.35	1.88	0.62	1.71	2.12	1.74
Phytate	0.61	0.62	0.44	0.87	2.91	0.46
Saponin	2.10	0.72	2.14	0.08	0.12	2.18
Oxalate	1.64	0.74	2.06	0.90	1.80	1.16
Cyanide	0.22	0.72	0.14	0.12	0.11	0.26
Flavonoid	1.22	1.64	1.68	1.20	3.00	1.38
			Sun drying			
Alkaloids	2.06	1.44	1.63	2.35	2.83	2.07
Phytate	1.08	1.24	1.82	1.58	2.22	0.99
Saponin	2.67	2.78	3.03	0.14	2.12	2.78
Oxalate	2.16	2.01	2.09	1.20	2.30	2.08
Cyanide	0.40	0.42	0.25	0.21	0.22	0.38
Flavonoid	0.46	2.67	2.37	1.74	3.96	1.93

SP = spinach, EW = ewedu, WL = water leaf, PL = pumpkin leaf, BL = bitter leaf, SS = sand sagebrush

Table 4 presents the differences between the raw and the processed vegetable samples. From the results obtained, processing had effect on the anti-nutrients content of the six varieties of vegetables employed in this study. The values obtained for the processed samples (steamed, boiled and sundried) were lower than values for the raw vegetables. The order of decrease was boiling > steaming > sun drying. This observation is in agreement with the findings of the Aganga and Tshwenyane (2003) and Richard (1991), who reported that boiling is superior in the reduction of anti-nutrients in vegetables than steaming and sun drying. Boiling reduced cyanide content by (32.56-45.83%), oxalate (19.27-44.76%), phytate (14.73-76.09%), saponins (21.01 – 94.42%), alkaloid (26.13-63.10%) and flavonoids (12.16-31-82%).

Steaming reduced alkaloids by (24.05-47.62%), phytate (14.29- 755.00%), saponins (10.82%-93.95%), oxalate (22.12-45.71%), cyanide 32.56-45.83%) and flavonoid (12.16-49.17%). Sun drying when compared to boiling and steaming methods had no significant decrease in the anti-nutrients. This observation is in line with the findings of Chewega and Nameus (1997) who stated that sun drying generally does not have significant effect on the minerals or other contents of vegetables because sun drying is a gradual evaporation process. The values ranged from (0.96-2.78%) for alkaloid, (0.62 – 2.94%) phytate, (0.37-30.00%), oxalate (0.92-4.00%), cyanide (0.00-27.59%) and flavonoids (0.50-1.91%).

Table 4: Difference in anti-nutrient composition between raw and processed vegetables

Parameters	SP	EW	WL	PL	BL	SS
			Steaming			
Alkaloids	0.7	0.04	0.8	0.57	0.74	0.64
	33.65%	2.74%	47.62%	44.50%	31.22%	30.47%
Phytate	0.39	0.32	1.38	0.65	0.32	0.57
	35.78%	25.40%	75.70%	40.88%	14.29%	55.88%
Saponin	0.29	1.10	0.96	0.10	2.02	1.52
	10.82%	39.00%	31.37%	50.00%	93.95%	55.07%
Oxalate	0.42	0.48	0.48	0.37	0.52	0.96
	19.27%	22.43%	22.64%	29.6%	22.12%	45.71%
Cyanide	0.14	0.14	0.10	0.12	0.11	0.18
	32.56%	33.33%	44.86%	41.38%	45.83%	45.00%
Flavonoid	0.18	0.78	1.18	0.57	0.83	0.58
	12.16%	29.77%	49.17%	32.39%	20.5%	29.90%
			Boiling			
Alkaloids	0.73	0.58	1.06	0.66	0.35	0.66
	35.10%	39.73%	63.0%	27.85%	26.13%	31.43%
Phytate	0.84	0.64	1.4	0.72	0.33	0.56
	44.04%	50.79%	76.09%	45.28%	14.73%	54.90%
Saponin	0.59	20.10	0.92	0.12	2.03	0.58
	21.64%	74.43%	30.07%	60.00%	94.42%	91.01%
Oxalate	0.42	0.48	0.48	0.37	0.52	0.94
	19.27%	82.43%	22.64%	29.60%	22.13%	44.76%
Cyanide	0.14	0.14	0.12	0.12	0.11	0.18
	33.56%	33.33%	42.56%	41.38%	45.82%	45.00%
Flavonoid	0.18	0.98	0.72	0.56	0.98	0.56
	12.16%	37.41%	30.00%	31.82%	24.62%	28.87%
			Sun drying			
Alkaloids	0.02	0.02	0.05	0.02	0.04	0.03
	0.96%	1.37%	0.78%	0.84%	1.39%	0.43%
Phytate	0.01	0.02	0.02	0.01	1.02	0.03
	0.92%	0.59%	1.09%	0.62%	0.89%	2.94%
Saponin	0.01	0.04	0.03	0.06	0.03	0.02
	0.37%	0.42%	0.98%	30.00%	1.40%	0.72%
Oxalate	0.02	0.05	0.03	0.05	0.05	0.02
	0.92%	2.34%	1.42%	4.00%	2.13%	0.95%
Cyanide	0.03	0.00	0.03	0.08	0.02	0.20
	0.98%	0.00%	10.71%	27.59%	8.33%	5.00%
Flavonoid	0.02	0.05	0.02	0.02	0.02	0.01
	0.35%	1.91%	1.75%	1.34%	0.50%	0.52%

SP = spinach, EW = ewedu, WL = water leaf, PL = pumpkin leaf, BL = bitter leaf, SS = sand sagebrush

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