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Full Length Research Paper

Effect of boiling time on the quality of '*Zogale*': A snack food produced from peanut (*Arachis hypogea*) cake and boiled *Moringa oleifera* leaves

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The effect of boiling time on the quality of "*Zogale*" was determined. *Moringa* leaves were boiled for 5, 10, 15, and 20 min, after which the various portions were blended with coarsely grounded peanut cake (kulikuli), in a ratio of 75 *Moringa* leaves: 25 kulikuli giving *Zogale* samples A, B, C, and D, respectively, while sample E (from the market) served as control. The proximate composition, pH, vitamins, minerals, toxicants and sensory properties were determined using standard methods of analyses. The results obtained show that while moisture and carbohydrate contents increased, all other parameters decreased significantly ($p < 0.05$) with boiling time. Vitamins, minerals and toxicants also decreased significantly ($p < 0.05$) with boiling time, with values for processed samples (A, B, C, and D) being higher than the control (E). The values for toxicants (total phenols, Oxalates, hydrogen cyanide, saponins, and alkaloids), which ranged from 12.37 to 3.44 mg/100 g, 4.62 to 2.14 mg/100 g, 3.24 to 0.94 mg/100 g, 1.34 to 0.23 mg/100 g, and 0.40 to 0.08 mg/100 g, respectively were all within safe acceptable limits. The pH of the samples decreased significantly ($p < 0.05$) with boiling time from 6.24 to 6.02, while that of the control was 5.58.

Key words: '*Zogale*', *Moringa*, 'kulikuli', boiling, quality, toxicants.

INTRODUCTION

Anozie (2009) observed that the basic reason for malnutrition and micronutrient deficiencies in the developing countries is the shift in dietary patterns in both urban and rural communities where traditional food systems are breaking down, and the shift is towards a western-type of cereal-based energy diets. A significant proportion of the diverse foods available in the environment have been neglected as technological options focus on few staple foods to address food security and hunger (Shrimpton et al., 2008).

Various approaches have been made by the World Health Organization and other related bodies to adopt resolutions for the control of micronutrient deficiencies. Such approaches or strategies have included school lunch programs nutrition education, introducing exotic vegetables, and even campaigns to give children massive doses of Vitamin A (FAO, 2008). A major drawback for many of these approaches is the dependence on imported solutions and foreign personnel. Progress in these approaches quickly dissipates, once the program funding dries up (Fuglie, 2000). There is therefore, need to look inwards for locally available foods that are nutritious, cheap and easy to prepare, to combat malnutrition.

The drumstick tree (*Moringa oleifera*) referred to as the "miracle plant" and known as "*Zogale*" in Hausa, "Okwe Oyibo" in Ibo, "Ewe Ile" in Yoruba and "Jeghel-Agede" in Tiv, is common throughout the West African region. Although, its medicinal uses have been known for long, it

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is only recently that the nutritional value of the different parts of the plant came to light. The leaves, pods, flowers and growing tips are all store houses of both the classic nutrients (carbohydrate, protein, oil, vitamins, and minerals) as well as beneficial non-nutrients (typically referred to as phytochemicals or phytonutrients). Almost all parts of the plant have nutritional and therapeutic value (Olusola, 2006). The raw leaves are outstanding as a source of vitamin A, B group and C (Gernah and Sengev, 2011), and are among the best plant sources of minerals (Fuglie, 2000). They are excellent sources of protein (especially when dried), but poor in carbohydrates and fats, thus making them one of the best plant foods available in nature (Olusola, 2006). They can be cooked and eaten as a vegetable like spinach (Price, 2000).

Peanut is very important in the vegetarian diet. It has as much or more protein than meat and contains no uric acid or cholesterol (Pamplona-Rogers, 2006). Peanuts are therefore a fundamental food for vegetarians. In fact, they do not cause obesity but rather aid weight loss when they are used to replace other high caloric foods in the diet (Onyeike and Oguike, 2003), and since peanuts do not contain provitamin A nor vitamin C, vegetables such as *M. oleifera* leaves can compensate for these vitamin deficiencies.

Zogale is a delicious local salad-like snack food which is prepared by mixing boiled *M. oleifera* leaves with coarsely milled peanut cake ('Kulikuli') and some spices. It is very easy to produce and is commonly consumed by all age groups including the young, pregnant women, lactating mothers, and the elderly, in the northern regions of Nigeria. It has been used by rural dwellers for centuries (Kawo et al., 2009).

However, *Zogale* production has remained traditional and cultural, without any standards, therefore, giving rise to inconsistencies in quality. Different boiling times for the *Moringa* leaves used in the production of *Zogale* could significantly affect the organoleptic properties, thus, determining its acceptability.

The aim of this study was therefore, to standardize the boiling time of *Moringa* leaves for *"Zogale"* production.

MATERIALS AND METHODS

Procurement of raw materials

About 1.5 kg fresh tender leaves of *M. oleifera* were sourced from a *Moringa* tree in Federal Housing Estate, North Bank, Makurdi. About 2.0 kg of peanut (*Arachis hypogea*) (2010 harvest), table salt, dry chilli pepper, dry ginger, fresh tomatoes, fresh onions, and already prepared '*Zogale'* product were purchased from North Bank market, Makurdi.

Material preparation

Boiling of Moringa leaves

About 1.0 kg of *Moringa* leaves were washed twice in a 5.0% salt (sodium chloride) solution made with clean tap water in order to remove grubs and other impurities. The washed leaves were then left in a colander for about 5 min to drain, after which they were immersed in 2.0 L of boiling water and allowed to cook for 5, 10, 15, and 20 min. The boiled leaves were drained in colander and allowed to cool before being blended to obtain samples A, B, C, and D, respectively.

Production of peanut cake ("Kulikuli")

About 0.5 kg of shelled peanuts seeds (2010 harvest) were thoroughly sorted out and cleaned of stones, bad seeds, and other foreign objects. They were roasted in an aluminum saucepan and milled into a paste, after which about 250 ml of boiling water was added and the dough kneaded alternately and further expressed to release oil. The de-oiled cake (DOC) was then cut into small pieces of about 50 g and was fried in the oil already expressed until they turned a golden brown colour. They were then removed and allowed to cool, giving a product locally known as "Kulikuli".

Preparation of 'Zogale' samples

Boiled *Moringa* leaves and ground kulikuli were blended to give '*Zogale*' samples (A, B, C, and D) as earlier indicated. Peanut cake (kulikuli), dried pepper and ginger were coarsely ground in a mortar and pestle, while tomatoes and onions were sliced into thin slices. All the spices and additives were added in the same quantities to all the samples to give the desired taste.

Analysis of samples

Proximate analysis

Proximate composition (moisture, crude protein, crude fat, crude fibre, and ash content) of the samples was determined by the method of AOAC (2005), while carbohydrate was determined by difference (Ihekoronye and Ngoddy, 1985). Energy values were calculated using the Artwater factor.

pH and vitamin analysis

Hydrogen ion concentration (pH) was determined by the method described by Akpapunam and Safeh-Dedeh (1995). β-carotene (Pro-Vitamin A), riboflavin (B_2), niacin (B_3), and ascorbic acid (Vitamin C) contents were all determined using the method of AOAC (2005).

Mineral analysis

Selected minerals in the '*Zogale*' samples: phosphorous, potassium, sodium, iron, calcium, and magnesium were determined by X-ray Fluorescence Spectrometry (XPFS) (MINIPA 4 ED-XRF).

Toxicants

Phytic acid content was determined using the method described by Nkama and Gbenyi (2001), while total phenol content was determined by the Prussian blue method of Budini et al. (1980). The method described by Hudson and El-Difrawi (1979) was used to determine the saponin content in the samples. Oxalic acid content was determined by the method described by Day and Underwood (1986), while the alkaloid content was determined as described by

Table 1. Proximate composition (%) of the *zogale* samples.

Parameter	A	B	C	D	E	LSD
Moisture	$61.00^{d} \pm 0.01$	$61.08^{c} \pm 0.15$	$62.20^{b} \pm 0.20$	$63.26^{a} \pm 0.22$	$63.80^{a} \pm 0.24$	0.71
Crude protein	$16.10^{a} \pm 0.10$	$15.27^{a} \pm 0.08$	$14.60^{b} \pm 0.06$	$14.10^{b} \pm 0.10$	$12.40^{c} \pm 0.30$	0.91
Crude fat	$10.60^{a} \pm 0.01$	$10.50^{a} \pm 0.02$	$10.20^{b} \pm 0.01$	$10.10^{b} \pm 0.01$	$9.86^{c} \pm 0.02$	0.25
Crude fibre	$5.10^{a} \pm 0.03$	$4.70^{b} \pm 0.03$	$4.20^{c} \pm 0.02$	$4.00^{c} \pm 0.03$	$3.72^{d} \pm 0.03$	0.33
Ash	$4.00^{a} \pm 0.02$	$3.60^{b} \pm 0.03$	$3.25^{b} \pm 0.02$	$3.00^{b} \pm 0.02$	$2.62^{c} \pm 0.01$	0.35
Carbohydrate	$4.10^{c} \pm 0.15$	$4.83^{b} \pm 0.20$	$5.25^{b} \pm 0.18$	$5.54^{a} \pm 0.18$	$6.00^{a} \pm 0.10$	0.55
Energy (Kcal/100 g)	$177.10^{a} \pm 0.44$	$175.80^{b} \pm 0.28$	$173.39^{c} \pm 0.35$	$169.74^{d} \pm 0.40$	$168.74^{e} \pm 0.2$	0.80

Values are means ± standard deviations of triplicate determinants. Any two mean values bearing the same superscripts in the same row are not significantly differently ($p > 0.05$). A: *Zogale* (with leaves boiled for 5 min); B: *Zogale* (with leaves boiled for 10 min); C: *Zogale* (with leaves boiled for 15 min); D: *Zogale* (with leaves boiled for 20 minutes); E: *Zogale* purchased at North Bank Market (control); LSD: Least significant difference.

Onwuka (2005). Hydrocyanic acid was determined by the method of AOAC (2005).

Sensory evaluation

Sensory evaluation of the *Zogale* samples was carried out using the method of Iwe (2003). The panelists consisted of 20 persons from the University of Agriculture, Makurdi and the College of Agriculture, Lafia. A 5-point hedonic scale (5-like extremely, 1-dislike extremely) was used to rate the sensory attributes of colour, taste, mouth feel, aroma, and overall acceptability of the products. Each attribute was evaluated separately. At each session, each panelist judged 5 samples which were presented randomly, with fresh tap water used for mouth rinsing in between evaluations as described by Ihekoronye and Ngoddy (1985).

Statistical analyses

All determinations were carried out in triplicates. Values were subjected to analysis of variance (ANOVA) using GENESTAT 2005 edition. Least significant differences between means were determined as outlined by Ihekoronye and Ngoddy (1985).

RESULTS

Proximate composition

The proximate composition of the *Zogale* samples showed variation in different parameters (Table 1), while moisture content increased, all other parameters decreased significantly ($p < 0.05$) with boiling time. The moisture content of processed samples (A to D) was significantly ($p < 0.05$) lower than that of the control (E), with values ranging from 61.00% in sample A to 63.80% in E.

Crude protein content decreased significantly ($p < 0.05$) with boiling time ranging from 16.10 to 13.20% in samples A to E, respectively. However, samples A, B, C, and D had significantly ($p < 0.05$) higher protein content between 15.80 and 16.10% as compared to sample E (control) with 15.20%.

The fat content did not decrease significantly ($p > 0.05$) In processed samples with values ranging from 10.70% in A to 10.20% in D, with all the values, however, being significantly higher ($p < 0.05$) than sample E (control) with 9.86%. There was a significant difference ($p < 0.05$) in the crude fibre content of sample A to C, with values ranging from 5.10 to 4.20%; while samples C to E did not show any significant decrease ($p > 0.05$) ranging from 4.20 to 3.72%. There was a general decrease in ash content of the samples, with values for processed samples being significantly higher ($p < 0.05$) from 4.00% in A to 3.00% in D as compared to the control (E) with the value of 2.62%. There was a significant difference ($p < 0.05$) in the carbohydrate (CHO) content of the processed samples, with values ranging from 4.10 to 5.54%. The values for samples A to D were significantly lower ($p < 0.05$) than sample E (control) which gave a value of 6.00%.

Energy values range from 177.10 kcal/100 g in sample A to 168.74 kcal/g in sample E, with significant difference ($p < 0.05$) between the control and the processed samples.

pH and vitamins

Results of pH and vitamin content of *Zogale* samples are shown in Table 2. The pH values of the processed samples ranged from 6.24 in A to 6.02 in D, showing no significant ($p > 0.05$) difference among themselves, but significant difference ($p < 0.05$) with the control (E) which gave a value of 5.58. However, there was evidence of gradual decrease in pH with boiling time, with the *Zogale* samples heading towards acidity.

Generally, the content of all the vitamins decreased significantly ($p < 0.05$) with boiling time, with the values for processed samples being significantly higher ($p < 0.05$) than the control. ß-carotene values ranged from 3.12 mg/100 g in A to 2.79 mg/100 g in D, which were all significantly higher ($p < 0.05$) than the value of 2.24 mg/100 g for sample E (control). There was a significant decrease in the riboflavin (vitamin B_2) content of *Zogale*

Table 2. pH and some vitamins of the *zogale* samples.

Parameter	A	B	C	D	E	LSD	RDA
pH	$6.24^{a} \pm 0.02$	$6.12^{a} \pm 0.04$	$6.07^{a} \pm 0.06$	$6.02^{a} \pm 0.03$	$5.88^{a} \pm 0.04$	-	-
B-Carotene (mg/100 g)	$3.12^{a} \pm 0.12$	$2.99^{a} \pm 0.20$	$2.90^{a} \pm 0.35$	$2.79^{b} \pm 0.24$	$2.24^{c} \pm 0.30$	0.30	4.80
Riboflavin (mg/100 g)	$0.19^{a} \pm 0.01$	$0.16^{b} \pm 0.02$	$0.14^{c} \pm 0.02$	$0.10^{d} \pm 0.01$	$0.07^{e} \pm 0.01$	0.02	1.60
Niacin (mg/100 g)	$2.00^{a} \pm 0.03$	$1.96^{a} \pm 0.02$	$1.62^{a} \pm 0.04$	$1.59^{b} \pm 0.04$	$1.52^{b} \pm 0.02$	0.42	1.50
Ascorbic acid (mg/100 g)	$120.82^{a} \pm 0.25$	$90.60^{b} \pm 0.32$	$60.41^{c} \pm 0.24$	$30.21^{d} \pm 0.35$	$20.05^{e} \pm 0.20$	0.85	95.00

Values are means ± standard deviations of triplicate determinants. Any two mean values bearing the same superscripts in the same row are not significantly differently (p > 0.05). A: *Zogale* (with leaves boiled for 5 min); B: *Zogale* (with leaves boiled for 10 min); C: *Zogale* (with leaves boiled for 15 min); D: *Zogale* (with leaves boiled for 20 min); E: *Zogale* purchased at North Bank Market (control); LSD: Least significant difference; RDA: Recommended Daily Allowances.

Table 3. Mineral composition (mg/100 g) of the *zogale* samples.

Parameter	A	B	C	D	E	LSD	RDA
Calcium	$370.26^{a} \pm 0.03$	$368.40^{a} \pm 0.01$	$366.22^{a} \pm 0.02$	$365.85^{a} \pm 0.02$	$364.15^{a} \pm 0.03$	5.00	1000.00
Iron	$2.73^{a} \pm 0.04$	$2.68^{a} \pm 0.03$	$.58^{a} \pm 0.02$	$2.50^{a} \pm 0.03$	$2.38^{a} \pm 0.02$	0.60	15.00
Magnesium	$15.76^{a} \pm 0.05$	$14.69^{b} \pm 0.04$	$14\ 63^{c} \pm 0.02$	$13.92^{d} \pm 0.03$	$12\ 81^{e} \pm 0.02$	0.50	300.00
Phosphorus	$370.34^{a} \pm 0.01$	$260.26^{b} \pm 0.05$	$200.64^{c} \pm 0.02$	$150.07^{d} \pm 0.03$	$140.48^{e} \pm 0.02$	0.85	700.00
Potassium	$180.49^{a} \pm 0.01$	$145.39^{b} \pm 0.03$	$124.03^{c} \pm 0.02$	$112.47^{d} \pm 0.02$	$100.23^{e} \pm 0.01$	2.30	2000.00
Sodium	$102.34^{a} \pm 0.02$	$100.22^{b} \pm 0.03$	$97.86^{c} \pm 0.02$	$92.19^{d} \pm 0.02$	$88.18^{e} \pm 0.01$	1.63	500.00

Values are means ± standard deviations of triplicate determinants. Any two mean values bearing the same superscripts in the same row are not significantly differently (p > 0.05). A: *Zogale* (with leaves boiled for 5 min); B: *Zogale* (with leaves boiled for 10 min); C: *Zogale* (with leaves boiled for 15 min); D: *Zogale* (with leaves boiled for 20 min); E: *Zogale* purchased at North Bank Market (control); LSD: Least significant difference; RDA: Recommended Daily Allowances.

samples with values ranging from 0.19 mg/100 g in A to 0.07 mg/100 g in E (control).

Niacin (vitamin B_3) gave values ranging from 2.00 mg/100 g for A to 1.59 mg/100 g for D, which were significantly higher ($p < 0.05$) than the value of 1.52 for E (control), but not significantly different ($p > 0.05$) among themselves. Vitamin C values ranged from 120.82 mg in A to 30.21 mg/100 g in D. These values were all significantly higher ($p < 0.05$) than the value of 20.05 mg/100 g for the control (E) and significantly different ($p < 0.05$) among themselves.

Mineral content

Results of the mineral content of *Zogale* samples are presented in Table 3. The content of all the minerals decreased significantly ($p < 0.05$) with increased boiling time. However, for all the minerals determined, all the processed samples (A to D) had significantly ($p < 0.05$) higher content than the control sample (E). However, the reduction in calcium and iron content between the samples (A to E) was not significant ($p > 0.05$).

Toxicants

Table 4 presents the results of toxins and anti-nutritional factors of the *Zogale* samples. There was significant ($p < 0.05$) reduction in toxicants with increase in boiling time, with the values for processed samples (A to D) being significantly ($p < 0.05$) higher than the control sample (E).

Sensory evaluation

Table 5 presents the mean sensory scores of the *Zogale* samples. Though, there was general decrease in the scores for the different attributes with increase in boiling time, the differences are not significant ($p > 0.05$) among the processed samples a (A to C). However, there was significant ($p < 0.05$) difference between the samples (C to E) for all the attributes, with the processed samples scoring higher values.

Sample A scored highest in all the attributes and had the highest general acceptability of 4.25, followed by B (4.20), C (4.17), and D (4.15); while sample E (control) scored least and had the least acceptability of 2.67.

DISCUSSION

Proximate composition

The increase in moisture content of the *Zogale* samples could be due to the increased imbibitions of water with

Table 4. Some toxicants (mg/100 g) of the *Zogale* samples.

Parameter	A	B	C	D	E	LSD
Total phenols	$12.37^{a} \pm 0.50$	$10.45^{b} \pm 0.46$	$7.85^{c} \pm 0.38$	$5.62^{d} \pm 0.52$	$3.44^{e} \pm 0.42$	1.02
Oxalates	$4.62^{a} \pm 0.15$	$3.82^{b} \pm 0.20$	$3.24^{c} \pm 0.03$	$2.65^{d} \pm 0.10$	$2.14^{e} \pm 0.25$	0.50
Hydrogen cyanide (HCN)	$3.24^{a} \pm 0.04$	$2.80^{a} \pm 0.02$	$2.02^{b} \pm 0.01$	$1.25^{c} \pm 0.02$	$0.94^{c} \pm 0,03$	0.65
Saponins	$1.34^{a} \pm 0.01$	$1.08^{b} \pm 0.02$	$0.85^{b} \pm 0.01$	$0.48^{c} \pm 0.03$	$0.23^{c} \pm 0.01$	0.35
Alkaloids	$0.04^{a} \pm 0.01$	$0.35^{b} \pm 0.01$	$0.24^{c} \pm 0.02$	$0.16^{c} \pm 0.02$	$0.80^{d} \pm 0.01$	0.05

Values are means ± standard deviations of triplicate determinants. Any two mean values bearing the same superscripts in the same row are not significantly differently (p > 0.05). A: *Zogale* (with leaves boiled for 5 min); B: *Zogale* (with leaves boiled for 10 min); C: *Zogale* (with leaves boiled for 15 min); D: *Zogale* (with leaves boiled for 20 minutes); E: *Zogale* purchased at North Bank Market (control); LSD: Least significant difference.

Table 5. Mean sensory scores of the *Zogale* samples.

Parameter	A	B	C	D	E	LSD
Colour	4.90^{a}	4.45^{a}	4.40^{a}	3.75^{b}	2.63^{c}	0.80
Taste	4.15^{a}	4.10^{a}	4.00^{a}	3.70^{a}	2.98^{b}	0.68
Aroma	4.25^{a}	4.15^{a}	4.10^{a}	3.66^{b}	2.76^{c}	0.30
Mouth feel	3.95^{a}	3.85^{a}	3.60^{a}	3.20^{b}	2.64^{c}	0.40
General Acceptability	4.25^{a}	4.05^{a}	3.90^{b}	3.75^{b}	2.67^{c}	0.35

Values are means ± standard deviations of triplicate determinants. Any two mean values bearing the same superscripts in the same row are not significantly differently (p > 0.05). A: *Zogale* (with leaves boiled for 5 min); B: *Zogale* (with leaves boiled for 10 min); C: *Zogale* (with leaves boiled for 15 min); D: *Zogale* (with leaves boiled for 20 minutes); E: *Zogale* purchased at North Bank Market (control); LSD: Least significant difference.

boiling time. Muller (1988) explained that during boiling, cellulose is little affected but the middle lamella gets broken down by heat, thus making vegetables to take up water as the starch gelatinizes. The longer the boiling time, therefore, the higher the moisture content. The results here is therefore an indication that sample E (from the market) was boiled for a longer period than all the other samples.

The decrease in crude protein content could be attributed to leaching effect. Gernah and Ajir (2007) also reported a decrease in protein content with the boiling of cassava leaves. However, at the protein content of 15.20 to 16.10%, *Zogale* is considered a very good protein source as compared to other everyday foods like eggs (12.00%), white bread (7.80%), rice (6.50%), milk (3.30%), and potatoes (2.10%) as reported by Gamman and Sherrington (1990).

The decrease in the fat content of the *Zogale* samples, which was not significant (p > 0.05), could also be due to leaching effect and is consistent with the findings of Ebuehi et al. (2005) for cassava leaves. With the fat content of fresh *Moringa* leaves being already as low as 0.90% (Fuglie, 2000), the leaching of fat with boiling time was not enough to give significant decrease in the fat content of *Zogale* samples, which is mostly contributed by the peanuts. A small amount of fat is necessary in the diet in order to supply the essential fatty acids. About 2% of the total energy supplied as fat is sufficient to meet this need (Gamman and Sherrington, 1990). The fat content of the *Zogale* samples is therefore quite adequate for this purpose.

The decrease in crude fibre could be attributed to solubilization effect. With increased boiling time, more of the carbohydrate in the leaves could have been solubilized, thus, leading to the decrease in crude fibre values. Though, crude fibre does not contribute nutrients to the body, it adds bulk to food, thus facilitating bowel movements (peristalsis) and preventing many gastrointestinal diseases in man. Recommendations are that an average adult should consume 18 to 32 g of fibre daily (Fuglie, 2000). The crude fibre values of the *Zogale* samples are therefore adequate for normal biochemical processes.

The observed decrease in ash content could be due to leaching of the minerals into the water used for boiling. Ash content is an indication of minerals, which help to keep the body alkaline, and are very essential in the normal functioning of the body, since they are involved in many biochemical processes. With the values obtained for ash content (2.62 to 4.00%), *Zogale* is considered a very good source of minerals as compared to other everyday foods like sorghum (1.20%) and maize (1.42%) (Gamman and Sherrington, 1990).

The observed carbohydrate (CHO) content of boiled leaves of 4.10 to 6.00% is on the low side. Generally, raw *Moringa* leaves with a reported CHO content of 13.40%

(Fuglie, 2000) are not known to be a good source of carbohydrate. At a CHO content of about 25.00% (Aletor and Ojelabi, 2007), peanut cake is also not a good source of CHO even at 100% utilization. Thus, *Zogale* is not considered a good carbohydrate food. Being a salad, the energy values of 168.74 to 177.10 kcals/100 g are adequate.

pH and vitamins

Though, there was no significant change in pH, there was evidence of gradual decrease in pH with boiling time, with the *Zogale* samples heading towards acidity. This could be due to the leaching of alkaline components like proteins and minerals into the boiling water.

The ß-carotene values of 2.24 to 3.12 mg/100 g obtained for the *Zogale* samples are close to the recommended dietary allowance (RDA) of ß-carotene of 4.8 mg/100 g for a normal adult (Gamman and Sherrington, 1990). With the ß-carotene value of 6.80 mg/100 g reported for fresh leaves (Fuglie, 2000) and peanuts having no ß-carotene (Aletor and Ojelabi, 2007) the values obtained here could be what was left after the effects of heat and leaching as reported by Gernah and Sengev (2011). ß-carotene is the precursor to vitamin A which can be found in many plants, particularly, those with yellow, red or dark green coloring. Vitamin A is important for the development of good eyesight, healthy skin, hair, strong immunity, and resistance to infection.

The decrease in riboflavin content of the *Zogale* samples could be due to leaching and heat destruction. Vitamin B_2 helps the body to convert proteins, fats, and sugars into energy and also helps the body to repair and maintain tissues. RDA is 1.6 mg/100g (Fuglie, 2000), *Zogale* is therefore not a good source of this vitamin.

The report which shows that the reduction in the niacin content of the *Zogale* samples was not significant ($p > 0.05$) is consistent with the reports of Fahey (2005), that this, vitamin is not easily destroyed by heat. The little losses could have therefore been as a result of leaching. Niacin helps the body to release energy from CHO, fats, and protein metabolism. Deficiency can cause dimness of vision and eye muscle fatigue. Considering the RDA of 1.5 mg for adults, *Zogale* is a good source of niacin with the values of 1.52 to 2.00 mg/100 g obtained for the samples.

Vitamin C is known to be heat labile and easily oxidized during food processing (WHO, 2003). Thus, the drastic reduction from the reported value of 220 mg/100 g for fresh *Moringa* leaves (Fuglie, 2000) could be due to heat, oxidation, and leaching during boiling, as indicated by the decrease with increased boiling time. Since peanuts contain no vitamin C (Enwere, 1998), the only contribution of this vitamin to *Zogale* is from *Moringa* leaves. Vitamin C is essential for healthy development of bones, teeth, blood, and sex organs. Compared to other everyday sources of vitamin C like sweet potato (17 mg/100 g), tomato (45 mg/100 g), red pepper (7 mg/100 g), spinach (9 mg/100 g), and orange (98.20 mg/100 g) (Wardlaw, 2003), and *Zogale*, with 30.21 to 120.82 mg/100 g is a good source of vitamin C.

Mineral content

The general decrease in mineral content of the *Zogale* samples could be attributed to leaching effect as also reported by Gernah and Ajir (2007) for cassava leaves, while the lower values obtained for the market sample (E) could be an indication that leaves in sample E were boiled for a much longer period before being used in *Zogale* preparation. However, that the reduction in calcium and iron in the samples was not significant ($p > 0.05$) is in agreement with the report of Saidu and Pam (2009) that calcium and iron are not usually soluble in cooking liquid, thus, do not reduce drastically in quantity during cooking. Minerals are vital to the functioning of many body processes. They are critical players in nervous system functioning, other cellular processes, water balance, and structural (e.g. skeletal) systems. Based on the RDAs for the different minerals, *Zogale,* as constituted, appears to be low in minerals. However, considering that it is a snack food, it is a good source of minerals.

Toxicants

Considering the reduction in toxicant content with boiling time, the lower value recorded for the market sample (E) is also a clear indication that it was boiled for much longer time than the other samples (A to D). However, the values of toxicants were mostly within safe acceptable limits, as compared to other everyday foods and Nigerian leafy vegetables (Badifu and Okeke, 1992).

Sensory evaluation

The general decrease in the mean sensory scores for the different attributes of the *Zogale* samples with increase in boiling time is an indication that boiling of the leaves for too long adversely affects the organoleptic properties of *Zogale*. This could be the reason why sample A scored highest in all the attributes and had the highest general acceptability of 4.25, followed by B (4.20), C (4.17), and D (4.15); while sample E (control) scored least and had the least acceptability of 2.67.

Conclusion

From this work, it could be concluded that *Zogale* is a nutritious snack food with good protein and micronutrient content that could be used, especially by the low income group, to combat micro-nutrient malnutrition.

All the chemical/nutritional and sensory properties of *Zogale* were adversely affected by boiling of the *Moringa* leaves. The longer the boiling time, the less acceptable the product became. *Zogale* prepared by boiling *Moringa* leaves for 5 min gave the best results in terms of nutritional (macro and micro-nutrient) composition and quality, and had the highest acceptability in respect of sensory properties.

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