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Effect of Processing Methods on the Sensory Property and Micronutrient Compositions of African Spinach and Fluted Pumpkin Leaves

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Abstract

This work assessed the effect of processing methods on the sensory properties and micronutrient content of African spinach and fluted pumpkin leaves. Using an experimental study design, six samples of each of the vegetables were processed into squeezed, blanched, fresh-dried, squeezed-dried, and blanched-dried, with the fresh leaves as the control. These samples were subjected to mineral and vitamin analysis while sensory evaluation was performed on egusi soup cooked with processed vegetables using standard methods. The result of the sensory evaluation indicated that squeezed pumpkin (SP) and squeezed African spinach (SAS) were the most preferred in terms of general acceptability with scores of 8.50±0.26 and 8.50±0.25 respectively. Squeezed dried Pumpkin (SDP) and blanched dried African spinach (BDAS) were the least accepted, with a score of 5.35±0.58 and 5. 29±0.34 respectively. Higher concentration of Beta carotene, vitamin C, calcium, iron, sodium, potassium and magnesium) were found in the fresh control. Blanching, squeezing, and drying significantly ($p<0.05$) decreased the micronutrient content of the vegetables. The findings of this study showed that squeezing can be an alternative method to blanching and drying for processing African spinach and fluted pumpkin for egusi soup, in terms of acceptability. Direct air-drying of pumpkin and African spinach (DP and DAS) preserved most of the micronutrients, therefore, dried shelf-stable products can be used to ensure food security.

Key words: African spinach, Fluted pumpkin, Blanching, Squeezing, Drying.

Introduction

African spinach (*Amaranthus hybridus*) and Fluted pumpkin (*Telfairia occidentalis*) leaves are prominent leafy vegetables widely consumed across Africa especially in Nigerian cuisine (Noah and Alaba, 2020). Fluted Pumpkin is referred to as *Eweroko* in Yoruba, *Kabewa* in Hausa land *Ugu* in Igbo land (Ogori et al., 2015). African Spinach is referred to as green in the local market, *Inine* in Igbo, *Efo tete* or *teteeleegun* in Yoruba, *allayahu* in Hausa and *alefu* in Tiv.

African Spinach leaves and fluted pumpkin are available all year round especially in Benue but are more abundant and cheaper during wet seasons. These vegetables are highly perishable due to their high water content and the non-availability of adequate storage and processing facilities to ensure shelf-stability (Pande et al., 2000).

These green leafy vegetables provide a cheap source of vitamins, minerals and dietary fibre (Akpasi et al., 2023). They are an excellent source of vitamins A, C E, K and vitamin B9. Minerals such as calcium, iron, magnesium, potassium, phosphorus and sodium (Akanbi et al., 2007). These vegetables are not only valued for their nutritional benefits but also their sensory attributes, including taste, texture, aroma and colour.

African spinach and fluted pumpkin leaves are usually subjected to various methods of preparation and cooking such as washing, shredding, squeezing, blanching, boiling, steaming and drying to preserve their nutrients, improve their palatability, ensure food safety and extend their keeping quality (Oboh & Aigbe, 2011). The method used depends on the choice of the person and how it should be served as an accompaniment, in soups, stews or sauces (Darkwah, 2013). Each processing method can impact the sensory attributes of African spinach and fluted pumpkin leaves differently, ultimately affecting consumer acceptance and preference. These indigenous vegetables have been under-exploited, especially in the northern part of the country particularly Benue state of Nigeria, where their usage is limited to inclusion in soups and sauces. Most often times, these vegetables are prepared using household techniques that affect their nutritional availability and sensory properties. Evaluating these household processing techniques will enlighten consumers on the specific methods these vegetables can be prepared to ensure nutrient retention, satisfy consumer's organoleptic desires and ensure food security. This study sought to process African spinach and fluted pumpkin using methods like blanching, squeezing, drying, squeeze-drying and blanch-drying and determine the micronutrient content of the different processed samples and their sensory characteristics in egusi soup.

Materials and Methods

***Study Design*:** The study design used in this study is experimental study design.

***Material Procurements and preparations*:** Six bunches of 200 g per weight each of freshly harvested African Spinach (*Amaranthus Cruentus*) and fluted pumpkin (*Telfairia occidentalis*) were procured at ₦100 each from Wurukum market, Makurdi, Benue state. The fresh vegetable samples were loosely packed in a sack in order to minimize heat build-up and maintain freshness, and then taken to the laboratory for further processing.

African Spinach and Fluted Pumpkin Processing: African spinach and fluted pumpkin leaves were processed separately to get six samples each. The green leafy vegetable samples were separated from the stalks and washed separately in 5% salt-water concentration to remove adhering dirt and also to get rid of microorganisms, insecticide and pesticides which may be on the leaves, followed by rinsing with running tap water and set aside in large plastic sieves to drain the water. The first vegetable samples were cut and kept fresh as the control. The second samples were cut and squeezed by rubbing in between palms to bruise the leaves and kept fresh. The third samples were cut, blanched by submerging the vegetable into boiling water for 30 seconds. They were immediately drained with a plastic sieve and rinsed with cold water to halt the cooking process and kept aside. The forth samples were cut and spread directly under fan and dried for 24 hours. The fifth samples were cut and squeezed by rubbing in between palms to bruise the leaves and dried under fan for 24 hours; The sixth samples were cut, blanched by submerging the vegetable into boiling water for 30 seconds, immediately draining with a plastic sieve and rinsed with cold water to halt the cooking process, then spread thinly on a sack and dried under fan for 24 hours.

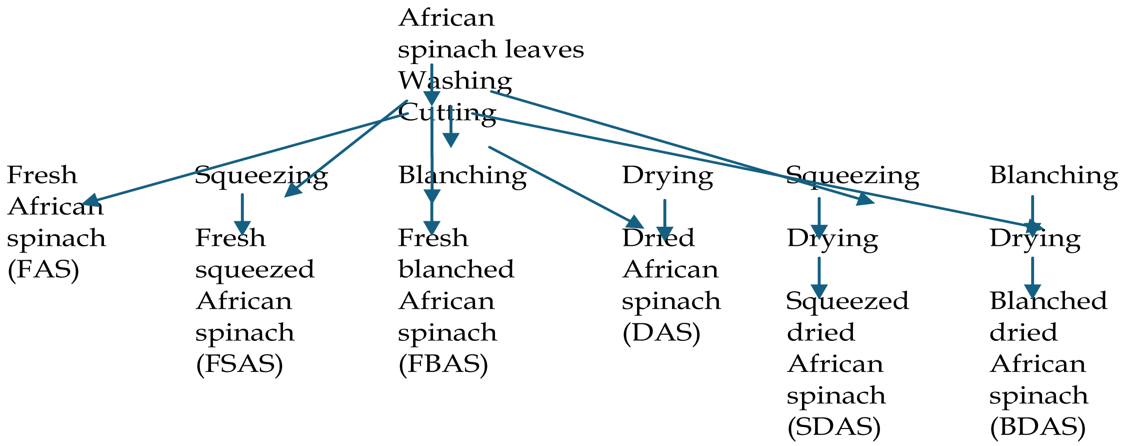

Fig 1: Flow charts for the various processing methods given to African spinach

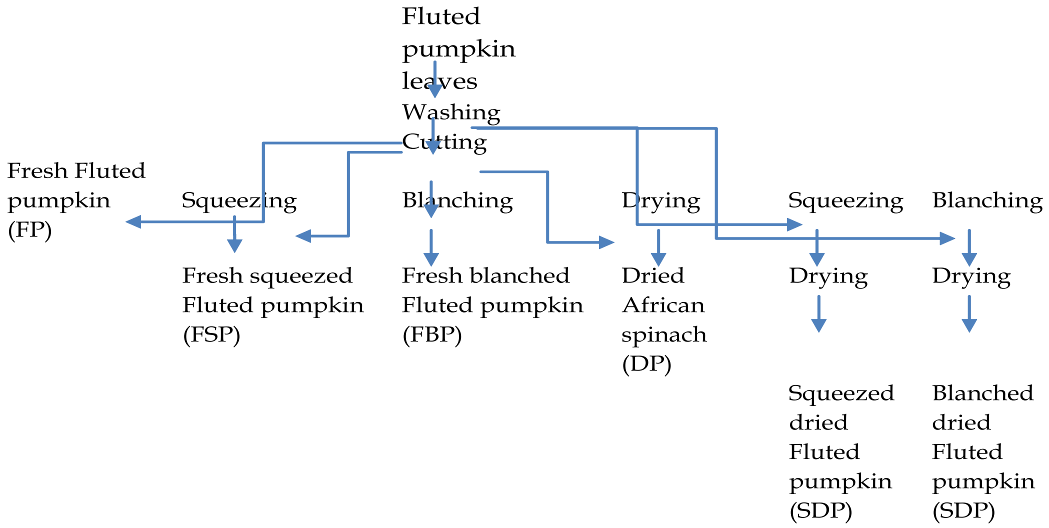

Fig 2: Flow charts for the various processing methods given to Fluted pumpkin

***Chemical Analysis*:** Mineral content (calcium, iron, sodium, magnesium and potassium) of the vegetable samples were determined using Atomic Absorption Spectrophotometry (AAS model UNICAM 969 Solar) as described by AOAC (2012). Vitamin A was determined by the adaptation of the method described by Alexander and Griffiths (1993) where the value of ß-carotene obtained was divided by 6 to get a rough estimate of Vitamin A); Vitamin C (Ascorbic acid) content was determined by UV Spectrophotometry and titrimetric method described by Mohammed et al. (2016).

***Egusi soup recipe*:** Egusi soup was prepared using 4 cups of milled melon seeds (egusi), 1 cup blended onions, 1 cup blended scotch bonnet and cayenne pepper mix, 8 cubes of Star maggi, salt to taste, 2 tablespoon of locust bean and 1 cup of palm oil.

***Egusi soup preparation*:** palm oil was heated in a large pot, pepper mix and onion were added into the oil to fry for 5 minutes, after which 3 cups of water was added. In a separate bowl, blended melon seed was mixed with a little water to form a paste. Lump sizes of the egusi paste were scooped out into the cooking pot and allowed to cook for 15 minutes. The solidified egusi lumps were pressed against the pot wall with a cooking spoon to break out into tiny bits. Blended crayfish, star maggi cubes, salt, and locust bean were stirred into the cooking pot and covered to cook further for 10 minutes. The cooked egusi soup was divided into 12 portions. The processed African spinach and fluted pumpkin leaves samples were each added into egusi soup separately and allowed to cook for 3 minutes.

***Sensory Analysis*:** Six samples each of egusi soup with pretreated African spinach and six samples of egusi soup with pretreated Fluted pumpkin leaves were coded and presented to 20 trained panelists who were familiar with the soup for sensory evaluation. The sensory evaluation was conducted in a standard sensory laboratory, where each of the panelists were positioned in a separate cubicle to avoid interference.

Samples were rated on the following attributes: colour, taste, texture, mouth feel and overall acceptability using a 9-point hedonic scale ranging from 9=like extremely and 1=dislike extremely.

***Statistical Analysis*:** Data collected were entered into Statistical Product for Service Solution (IBM-SPSS), version 21.0. Mean and standard deviation were used to analyse the data. All data obtained were subjected to Analysis of Variance (ANOVA) and the means separated using Duncan's multiple range test to detect significant difference ($p<0.05$).

Results

Table 1 shows the beta carotene, vitamin C, calcium, iron, sodium, magnesium, and potassium content of different processed African spinach leaf samples. Blanching, squeezing, and drying caused a significant ($p<0.05$) decrease in all the samples across all the analyzed micronutrients.

The Beta carotene content of African spinach samples was significantly higher in the control sample FAS (fresh African spinach) (control) (17.61±0.01 µg/100g) and lowest in squeezed dried African spinach (SDAS) (43.31±0.03 µg/100g). Vitamin C content was highest in fresh- African spinach- FAS (16.35±0.03) and lowest in squeezed dried African spinach- SDAS (31.21±0.03 mg/100g). Calcium content was highest in fresh African spinach-FAS (21.54±0.02) and lowest in squeezed dried African spinach- SDAS (72.64±0.03 mg/100g). Iron content was highest in sample fresh African spinach-FAS (14.15±0.02 mg/100g) while blanched dried African spinach-BDAS had the lowest value (39.32±0.02 mg/100g). Sodium content ranged from 49.31±0.01 to 89.65±0.01 mg/100g with fresh African spinach-FAS having the highest while squeeze dried African spinach-SDAS had the lowest value. Magnesium content ranged from 201.96±0.03 to 243.23±0.030.03 mg/100g with fresh African spinach-FAS having the highest while blanched dried African spinach-BDAS had the lowest value and potassium content was highest in fresh African spinach-FAS (133.75±0.030.02 mg/100g) and lowest in blanched dried African spinach-BDAS (267.55±0.02 mg/100g).

Table 1: Micronutrient content of different processed African spinach leaves samples

Sample codes	Beta-Carotene (µg/100g)	Vitamin C (mg/100g)	Calcium (mg/100g)	Iron (mg/100g)	Sodium (mg/100g)	Magnesium (mg/100g)	Potassium (mg/100g)
FAS	43.31ᵃ±0.03	31.21ᵃ±0.01	72.04ᵃ±0.01	39.32ᵃ±0.02	89.65ᵃ±0.01	243.23ᵃ±0.03	267.55 ᵃ±0.02
BAS	30.69ᵈ±0.01	22.69ᵈ±0.02	64.18ᶜ±0.03	34.86ᶜ±0.03	52.11ᵈ±0.02	221.29 ᶜ±0.01	228.65ᶜ±0.02
SAS	36.45ᶜ±0.03	25.41ᶜ ±0.03	54.32ᵈ±0.01	26.67ᵈ±0.01	61.28ᶜ±0.03	218.63ᵈ±0.03	209.12ᵈ±0.01
FDAS	39.69ᵇ±0.02	29.69ᵇ ±0.02	68.18ᵇ±0.03	37.86ᵇ±0.03	72.11ᵇ±0.02	231.29ᵇ±0.02	235.65ᵇ±0.03
BDAS	20.26ᵉ±0.03	20.19ᵉ ±0.03	21.54ᵉ±0.02	24.24ᵉ±0.03	49.31ᵉ±0.01	201.96 ᶠ±0.03	157.34ᵉ±0.03
SDAS	17.61ᶠ±0.01	16.35ᶠ±0.03	29.29ᶠ±0.02	14.15ᶠ±0.02	46.82ᶠ±0.03	207.63 ᵉ±0.03	133.75ᶠ±0.02

Values are means ± SD of triplicate determinations. Means within the sample column bearing different superscript are significantly different ($p<0.05$).

Key: FAS: Fresh African Spinach, BAS: Blanched African Spinach, SAS: Squeezed African Spinach, DAS: Fresh Dried African Spinach, BDAS: Blanched Dried African Spinach, SDAS: Squeezed Dried African Spinach.

Table 2 shows micronutrient content of different processed fluted pumpkin leaves samples. It was observed that the control sample FP was significantly ($p<0.05$) higher in micronutrients than the processed samples while blanching, squeezing and drying caused significant ($p<0.05$) decrease in all the samples across all the analyzed micronutrients compared to the control.

Beta carotene content of processed fluted pumpkin leaves samples ranged from 15.0±0.02 to 48.15±0.03 µg/100g with the control (FP) having the highest while BDP had the lowest value. Vitamin C content ranged from 22.41±0.03 to 57.43±0.02 mg/100g, with sample FP having the highest while BDP had the lowest value. The calcium content ranged from 18.58±0.03 to 61.18±0.03 mg/100g with sample FP having the highest while sample BDP had the lowest value. Iron content ranged from 16.26±0.03 to 36.54±0.01 mg/100g, FP having the highest while BDP had the lowest value. The sodium content ranged from 21.75±0.03 to 44.03±0.02 mg/100g, FP having the highest while BDP had the lowest value. The magnesium content ranged from 93.45±0.03 to 123.21±0.02 mg/100g, FP having the highest while BDP had the lowest value and the potassium content ranged from 108.43±0.01 to 134.78±0.03 mg/100g, FP having the highest while SDP had the lowest value.

Table 2: Micronutrient content of samples of processed fluted pumpkin leaves (mg/100g)

Samples	Beta Carotene	Vitamin C	Calcium	Iron	Sodium	Magnesium	Potassium
FP	48.15ᵃ±0.03	57.43ᵃ±0.02	61.18ᵃ±0.03	36.54ᵃ±0.01	44.03ᵃ±0.02	123.21ᵃ±0.02	134.78ᵃ±0.03
FBP	33.41ᵈ±0.03	42.12ᵈ±0.03	39.51ᵈ±0.03	21.64ᵈ±0.03	31.17ᵈ±0.03	117.65ᵈ±0.03	118.46ᶜ±0.03
FSP	35.69ᶜ±0.03	46.69ᶜ±0.01	42.66ᶜ±0.01	29.43ᶜ±0.02	32.24ᶜ±0.02	119.48ᶜ±0.01	112.91ᵈ±0.01
FDP	38.94ᵇ±0.03	49.32ᵇ±0.02	56.27ᵇ±0.01	34.13ᵇ±0.02	38.73ᵇ±0.02	122.48ᵇ±0.03	132.91ᵇ±0.01
BDP	15.04ᶠ±0.02	22.41ᶠ±0.03	18.58ᶠ±0.03	16.26ᶠ±0.03	21.72ᶠ±0.03	93.45ᶠ±0.03	108.33ᵉ±0.03
SDP	16.79ᵉ±0.03	24.65ᵉ±0.03	19.62ᵉ±0.03	20.74ᵉ±0.03	24.17ᵉ±0.03	96.16ᵉ±0.01	102.45ᶠ±0.01

Values are means ± SD of triplicate determinations. Means within the sample column bearing different superscript are significantly different ($p<0.05$).

Key: FP: Fresh Pumpkin, FBP: Fresh Blanched Pumpkin, FSP: Fresh Squeezed Pumpkin, DP: Dried Pumpkin, SDP: Squeezed Dried Pumpkin, BDP: Blanched Dried Pumpkin.

Table 3 shows the result of sensory evaluation of different processed African spinach leaf samples in egusi soup. The sensory score for colour was rated highest for squeezed African spinach (8.50±1.21) and lowest in blanched dried African spinach (5.32±0.67). No significant differences ($p<0.05$) existed between samples BAS and SAS. The sensory score for taste was highest in blanched African spinach-BAS (7.70± 0.73) and lowest in squeezed dried African spinach-SDAS (5.45±0.67). No significant difference ($p<0.05$) existed between samples FAS, BAS and SAS, and also between samples BDAS and SDAS. The texture attribute was significantly ($p<0.05$) higher blanched African spinach-BAS (8.75±0.82) and lowest for blanched dried African spinach-BDAS (5.00±0.73). No significant differences ($p<0.05$) were observed between samples BAS and SAS, and also between samples BDAS and SDAS. The sensory score for mouthfeel was rated highest for fresh African spinach-FAS (8.69±0.81) and lowest in squeezed dried African spinach-SDAS (5.62±0.32). No significant difference were found between samples FAS and SAS, and also between samples FDAS and BDAS. The General acceptability of the processed African spinach samples was rated highest for squeezed African spinach-SAS (8.50±0.25) while squeezed dried African spinach-SDAS (5.29±0.34) was rated lowest. N significant differences existed between samples BAS and SAS, and also between samples FDAS and BDAS.

Table 3: Sensory evaluation of egusi soups prepared from different processed African spinach leaves

Samples	Colour	Taste	Texture	Mouthfeel	General acceptability
FAS	7.60^{b}±0.86	7.55^{a}±1.00	7.64^{b}±0.86	8.69^{a}±0.81	7.78^{b}±0.23
BAS	8.34^{a}±0.73	7.70^{a}± 0.73	8.75^{a}±0.82	7.21^{b}±0.49	8.33^{a}±0.41
SAS	8.50^{a}±1.21	7.45^{a}±0.51	8.60^{a}±0.81	8.62^{a}±0.23	8.50^{a}±0.25
FDAS	6.43^{c}±0.73	6.20^{b}±0.98	6.20^{c}±0.98	6.27^{c}±0.75	6.75^{c}±0.16
BDAS	5.32^{e}±0.67	5.90^{c}±0.72	5.35^{d}±0.68	6.54^{c}±0.12	5. 63^{c} ±0.72
SDAS	6.03^{d}±0.73	5.45^{c}±0.67	5.00^{d}±0.73	5.62^{d}±0.32	5. 29^{d} ±0.34

Values are means ± SD of triplicate determinations. Means within the sample column bearing different superscript are significantly different ($p<0.05$).

Key: FAS: Fresh African Spinach, BAS: Blanched African Spinach, SAS: Squeezed African Spinach, DAS: Fresh Dried African Spinach, BDAS: Blanched Dried African Spinach, SDAS: Squeezed Dried African Spinach.

The result of the sensory evaluation of different processed fluted pumpkin leaves is shown in table 4 below. No significant difference ($p<0.05$) existed between samples FP (fresh pumpkin), FBP (fresh blanched pumpkin) and FSP (fresh squeezed pumpkin) for colour, while (FSP) fresh squeezed pumpkin was rated highest and (BDP) blanched dried pumpkin was rated lowest for colour, with values of 4.90±0.72 and 8.54±0.41 respectively. No significant differences ($p<0.05$) existed between samples FP, FBP and FSP for taste, but sample FBP was rated highest with a sensory score of 8.50. The Texture attribute was observed to be in the range 6.08±0.64 to 8.57±0.22 for squeezed dried pumpkin (SDP) and fresh squeezed pumpkin (FSP) respectively. No significant differences ($p<0.05$) existed between samples FP and DP and also between samples FBP, DP and BDP. The sensory attribute for mouthfeel was rated highest for FSP while SDP was rated lowest with values of 8.62±0.51 and 5.63±0.67 respectively. No significant differences ($p<0.05$) existed between sample FBP and FSP.

General acceptability of the different processed fluted pumpkin leaves in egusi soup scored highest in sample FSP while sample SDP scored lowest with scores of 8.50±0.26 and 5.35±0.58 respectively. No significant differences ($p<0.05$) existed between samples FP, FBP and DP and also between samples SDP and BDP.

Table 4: Sensory evaluation of egusi soups prepared from different processed fluted pumpkin leaves

Samples	Colour	Taste	Texture	Mouthfeel	General acceptability
FP	8.40[a]±0.24	8.33[b]±0.24	7.89[b]±0.38	7.95[b]±0.26	7.75[b]±0.17
FBP	8.50[a]±0.48	8.50[a]±0.23	7.62[c]±0.98	8.34 [a]±0.55	7.12 [b]±0.33
FSP	8.54[a]±0.41	8.37 [a]±0.73	8.57[a]±0.22	8.62[a]±0.51	8.50[a]±0.26
DP	7.75[b]±0.49	7.55[c]±0.16	7.33[b]±0.72	6.95[c]±0.72	7.42[b]±0.72
SDP	5.20[c]±0.98	6.77[d]±0.03	6.08[c]±0.64	5.63[e]±0.67	5.35[c]±0.58
BDP	4.90[d]±0.72	6.35[e]±0.26	6.34[c]±0.12	6.20[d]±0.63	5.74[c]±0.15

Values are means ± SD of triplicate determinations. Means within the sample column bearing different superscript are significantly different ($p<0.05$).

Key: FP: Fresh Pumpkin, FBP: Fresh Blanched Pumpkin, FSP: Fresh Squeezed Pumpkin, DP: Dried Pumpkin, SDP: Squeezed Dried Pumpkin, BDP: Blanched Dried Pumpkin.

Discussion

Micronutrient

Blanching, squeezing, and drying significantly decreased the concentration of Beta carotene, vitamin C, calcium, iron, sodium, magnesium, and potassium content of both African spinach and fluted pumpkin leaves. The control samples i.e fresh African spinach (FAS) and fresh fluted pumpkin (FP) had significantly ($p<0.05$) higher concentrations in all the analyzed micronutrients. This implies that processing affected the micronutrient content of the processed vegetables. Dried samples, particularly Fresh Dried African Spinach and Fresh Dried Pumpkin ranked second to the control samples in terms of their micronutrient contents. This corresponds with the report of Mepba et al. (2007) who also reported higher concentrations of minerals in raw and sun-dried green vegetable samples.

Beta carotene content of different processed samples of fluted pumpkin leaves which ranged from 16.79±0.03 to 43.31±0.03 µg/100mg, is significantly higher than the values reported by Otitoju et al. (2014). While beta carotene content of African spinach which ranged from 16.35±0.03 to 31.21±0.01 µg/100mg is comparable to the values reported by Rejeki et al. (2023). The values reported in this study were significantly lower than the RDA of 770 µg/day (Ahmed et al., 2023). Beta carotene (vitamin A) is important for the maintenance of healthy eyes and skin, normal growth and reproduction as well as enhancement of immune function (Ukom& Obi, 2018).

According to Oboh (2005) and Sobowale et al. (2010), processing such as squeezing, blanching, and drying leads to significant losses in the vitamin C content of vegetables. The vitamin C content of different processed samples of African spinach which ranged from 16.35±0.03 to 31.21±0.01 mg/100g is comparable to the values reported by Ejoh et al., (2019). The vitamin C content of different processed samples of fluted pumpkin leaves which ranged from 22.41±0.03 to 57.43±0.02 mg/100g is comparable to the values reported by Oguguo (2018).

The mineral content of the fresh samples was significantly higher than the squeezed and blanched samples but the dried samples particularly Fresh Dried African Spinach and Fresh Dried Pumpkin ranked second.Otitoju et al. (2014) also reported reduced levels of calcium, iron, sodium, and magnesium iron during the processing of leafy vegetables.

The calcium content of different processed samples of African spinach which ranged from 21.54±0.02 to 72.04±0.01 mg/100g and different processed fluted pumpkin samples which ranged from 18.58±0.03 to 61.18±0.03 mg/100g are reportedly lower than the 400mg/100g of

RDA of calcium (SON, 2010). This implies that other sources of calcium will be needed to boost the calcium intake per day, especially for pregnant women and growing children. Calcium is required for skeletal formation in foetus and strong bones and teeth (Kayode & Kayode, 2011).

The iron content of different processed samples of African spinach and fluted pumpkin in this study ranged from 14.15±0.02 to 89.65±0.01 mg/100g and 16.26±0.03 to 36.54±0.01 mg/100g respectively and are significantly higher than the RDA of 10 mg to 15 mg (Oluwole & Agboola, 2018). The high amount of iron recorded here is in line with the observation of Agogbua et al. (2022) who reported that the leaves of fluted pumpkin are rich sources of iron. However, iron found in plants is non-heme (iron from plant-based foods) and, therefore, is less bioavailable for human absorption unlike the iron from animals which is more bioavailable (Richard and Ines, 2010). Iron is essential for blood production (Gwer et al., 2020).

The sodium content of different processed samples of African spinach was 46.82±0.03 to 89.65±0.01 mg/100g and that of the fluted pumpkin samples ranged from 21.72±0.03 to 44.03±0.02 mg/100g. The values obtained in this study are categorized as low sodium levels. The recommended daily limit is less than 2000mg/day, that is, one teaspoon of table salt (Zubairi et al. (2022). Sodium is required by the body in relatively small amounts to maintain a balance of body fluids and keep muscles and nerves running smoothly (Veniamakis et al., 2022).

The magnesium content of different processed African spinach samples reported in this study (201.96±0.03 to 243.23±0.03 mg/100g) and that of fluted pumpkin (93.45±0.03 to 123.21±0.02 mg/day) were significantly lower than the RDA of 400mg/day for men (Sobowale et al., 2010), but can provide up to 50.49% to 60.81% and 23.36% to 40.80% respectively of the RDA.

The potassium content of different processed African spinach samples which ranged from 133.75±0.03 to 267.55±0.02 mg/100g can only provide 6.7% to 13.4% of the RDA 2000 mg/day (Sobowale et al., 2010). While the different processed fluted pumpkin samples in the range 102.45±0.01 to 118.46±0.03 mg/100g can provide 5.1 and 5.9 of the RDA for potassium. The values obtained in this study is significantly ($p<0.05$) lower than the RDA of potassium

Sensory Evaluation

The processing methods used in this study which included blanching, squeezing, and drying had a significant effect on the sensory attributes of these vegetables. The study showed that the general acceptability values of freshly squeezed African spinach and freshly squeezed pumpkin rated higher than the control (fresh African spinach and fluted pumpkin) with sensory scores of (8.50±0.25) and 8.50±0.26 respectively. Although some of the processed samples were not significantly different ($p<0.05$) from each other, in the evaluated sensory attributes (colour, texture, mouthfeel, and general acceptability), all the samples had acceptable sensory scores, as they were all scored five and above. This implies that processing may not have necessarily altered the sensory properties of vegetables when used for soups. This agrees with the report obtained by Mepba (2007), where vegetable soup samples of processed African spinach and fluted pumpkin scored above 5 in sensory analysis. Egusi soups prepared with freshly squeezed African spinach and freshly squeezed fluted pumpkin were rated significantly higher for colour, texture and overall acceptability. This contradicts the report of Sobowale et al., (2010) where the panelists rated fresh unprocessed fluted pumpkin higher than treated vegetables. The significantly higher score for colour, texture and overall acceptability observed in fresh squeezed fluted pumpkin and fresh squeezed African spinach could be attributed to the squeezing effect. Squeezing of vegetable breaks down the structures inside and outside of the leaf cells, in turn, softens the tough texture of leaves and also exposes some of the leaf juices (chlorophyll), and the immediate cooking inactivates oxidative enzymes which prevent co-mingling of the leaves with the substrate (soup) that allows discoloration of the leaves (Pelalak, 2021). Green vegetables that retain or intensify their greenish colour after cooking imply that most of the nutrients are still available and not destroyed by heat (Marangoni, 2017).

Fresh blanched African spinach and fresh blanched fluted pumpkin were rated significantly higher for taste. This may be because blanching inactivates enzymes responsible for flavor, hence stabilized the flavor components of the vegetable in egusi soups. This agrees with the study of Sobowale et al. (2010), that blanching of vegetables also improves the taste of vegetables.

Amongst the dried samples, the lowest likeness to colour of Blanched Dried African Spinach and Blanche Dried Pumpkin could be as a result of the blanching process which has the potential to trigger the production of chlorophyll derived substances (Leite et al., 2018) and on exposure to air during the drying process, results to a darkish discoloration as a result of oxidation. This contradicts the result of Pandey et al., 2016 that blanching before drying maintained the greenish colour of green peas, this disparity maybe as a result of the difference in the drying method used. The texture profile of BDAS and BDP were noticeably chewy with a fibrous texture. This indicates that BDAS and BDP would likely have more fibre than the other vegetable samples.

Conclusion

The study showed that blanching, squeezing and drying had a significant effect on the micronutrient content of African spinach and fluted pumpkin leaf samples. Amongst the processed samples, drying of the vegetables without intermittent processing such as in dried African spinach and dried pumpkin had the maximum micronutrient retention compared to the other methods. African spinach leaf samples are richer sources of calcium, iron, sodium, and potassium compared to pumpkin leaf samples which are richer in beta-carotene, vitamin C, and magnesium. The micronutrient content of the dried vegetables was comparable to that of the fresh sample, and therefore could provide an alternative form of using the vegetables in traditional soups. Processing also influenced the sensory attributes of the vegetables as acceptance levels were significantly different amongst the different processed samples in egusi soup. Both Fresh squeezed Pumpkin leaves and Squeezed African spinach were the most preferred sample in terms of colour, mouthfeel, texture and general acceptability, hence Fresh Squeezed Pumpkin and Squeezed African Spinach could be used as an acceptable processing method to satisfy consumer’s organoleptic desires.

Recommendations

1. Awareness campaign should be carried out on the importance of drying pumpkin leaves and African spinach using air as the drying medium, as it preserves the greenish colour of vegetables and also extend the shelf life of the vegetables. Thereby curtailing the issues of post-harvest losses and ensuring food security.
2. Nutritionist can encourage people to prepare and consume African spinach and fluted pumpkin leaves using appropriate processing method so as to harness the micronutrients embedded in

these vegetables. Pumpkin leaves can be milled stored in a glass jar and be used as nutrient fortificant in gruel and porridges.

3. Further studies are required to determine the proximate composition of the various processed samples of the vegetables in egusi soups. Further work should also be carried out to determine how long the dried products can retain its greenish colour during storage.

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