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Nutritional and Anti-Nutritional Composition of Fermented/Pickled Garden Egg (*Solanum aethiopicum* L.)

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ABSTRACT

Garden egg (*Solanum aethiopicum* L.) is highly perishable. Shelf life of the crop can be extended via pickling. Therefore, this study focused to observe the pickled garden egg, in order to make it available in and out of season. Three samples were prepared, namely unpickled (control) garden egg (UPRGE); pickled garden egg in brine with sugar (PGESU); and pickled garden egg with salt (PGESA). Samples were pickled for seven days and evaluated for the nutritional, phytochemicals and sensory qualities using standard methods. On dry weight basis, moisture contents ranged from (1.11 to 1.12 %), protein ranged from (13.8 to 19.5 %), ash ranged from (12.7 to 18.0 %), fiber ranged from (8.5 to 15.8 %), fat ranged from (2.7 to 5.4 %) and the available carbohydrates ranged from (45.1 to 54.3 %). There was significance difference ($p<0.05$) in protein, ash, crude fiber, and carbohydrates. The mineral compositions were as follows: Potassium (183.0 to 183.7 mg/g), magnesium ranged from (162.3 to 194.5 mg/g), calcium ranged from (105.6 to 207.3 mg/g), copper ranged from (67.9 to 747.1 mg/g) and sodium ranged from (315.4 to 346.2 mg/g). Vitamin C ranged from (3.25 to 3.37 mg/g), saponin ranged from (10.74 to11.58 mg/g) and tannin (1.93 to 2.73 mg/g). Unpickled garden egg was scored higher in all of the sensory attributes. Conclusively, although pickling improves the nutritional composition of garden egg, and reduces the anti-nutritional content, the raw samples were preferred.

Keywords: Pickling; garden egg; phytochemical; proximate; minerals

INTRODUCTION

Garden egg (*Solanum aethiopicum* L.) also called eggplant belongs to the family *Solanaceae* which has over 1000 species worldwide. According to Bergley (2009), there are about 25 species including domesticated and wild types, with the leaves, and fruits used as vegetables or in traditional medicine in Nigeria. Garden egg is a popular traditional vegetable in tropical Africa, called "afufa" in Igbo, "dauta" in Hausa and "Igba" in Yoruba (Anosika *et al.*, 2012). It is one of the healthiest foods one can consume (Bergley, 2009), composed of approximately 92% water, 6% carbohydrates, 1% protein, good source of dietary fiber and negligible fat. Furthermore, it is rich in minerals such as potassium, manganese, copper, magnesium, phosphorus and vitamins such as folate, niacin, thiamine (vitamin B1) and vitamin K.

Garden egg contains phytonutrient such as Nasunin and Chlorogenic acid (Noda *et al.*, 2000). Nasunin is found in the skin of the fruit, a potent antioxidant and free radical scavenger. Furthermore, nasunin has been revealed to prevent destruction of cell membrane that can promote cancer and lessening free radical damage in joints (Anosika *et al*., 2012). Due to the nutritional contents of garden egg, consumption has been documented to have a lot of health benefits, including weight loss, lowering of cholesterol, lowering of blood sugar, improvement in vision and increases vitamin K level (Eze and Kanu, 2014).

The phytochemicals in garden egg such as oxalates, tannin, saponin and alkaloids are considered as anti-nutrients since it has been documented to chelate with minerals (Eze and Kanu, 2014). However, pickling/fermentation process has been shown to reduce the anti-nutritional content of crops (Saranya and Ranjani, 2017).

The perishability of garden egg is similar to that of cucumber (*Cucumis sativus L.*) which is about 10 to 14 days after harvest at optimum temperature of 10 to 12 ^{0}C and relative humidity of more than 80% (Snowdon, 1990). In order to improve the perishability of garden egg, similar forms of preservation applied to cucumbers can also be applied to make them available in and out of season (Snowdon, 1990).

Preservation techniques used for cucumbers include pickling, which also increases nutritional value of the foods (Lee and Kang, 2004). Cucumbers are often preserved by making them into pickles. Pickling is one of the oldest known methods of food preservation technique used in foods especially vegetables (Okafor, 2007). A wide range of vegetables and fruits can be pickled including onions, tomatoes, carrots, mangoes and cucumbers (Okafor, 2007) and the process involves anaerobic fermentation in acidic environment usually vinegar (Egbe *et al*., 2017). Other materials such as sugar, salt, spices, red pepper flakes, cinnamon sticks, mustard seed and bay leaves could be added into the brine solution (Kolbe and Kramer, 2007). Furthermore, this method of preservation could be applied to indigenous crop such as garden egg. In Nigeria, this fruit is usually consumed raw or cooked in sauce but never pickled. Therefore, the focus of this study was to pickle garden egg with the goal of making it available in and out of season.

MATERIALS AND METHODS

Materials

About 2 kg of mature but unripe fresh garden eggs (*Solanum aethiopicum* L.) variety was purchased from Beere market in Ibadan, Oyo State and was transported to Food Science and Technology Laboratory. Apple cider vinegar, sugar, salt and pickling jars with lids were also procured.

Methods

Preparation of samples

The gardens eggs were sorted to remove dirt, unwanted particles and damaged fruits. The stalks were removed with stainless knife and washed in portable water and divided into three sample groups of 0.6 kg each.

Group A: Unpickled garden egg (UPRGE)
Group B: Pickled Garden egg with sugar (PGESU)
Group C: Pickled Garden egg with salt (PGESA)

Preparation of brine

Brine solution with sugar was prepared according to (Kolbe and Kramer, 2007). Briefly, 1 L of distilled water, 1 L of apple cider vinegar, 16 g of salt and 38.9 g of sugar was heated to 100 ^{0}C for 5 min so as to allow the solution to dissolve properly and then it was cooled to room temperature (32 ± 2 ^{0}C). Brine solution without added sugar was also prepared as previously mentioned.

Pickling of Garden eggs

The garden eggs to be pickled were placed in a thoroughly cleaned jar along with a tight lid. Approximately 0.6 kg of garden eggs were placed in four jars and filled with 500 mL of brine with sugar, and left undisturbed at room temperature ($32 \pm 2\ ^0C$) to ferment for 7 days (Egbe *et al.,* 2017). Similar process was followed for the garden eggs pickled with brine without added sugar. Portions of samples were taken immediately following pickling for sensory analysis and determination of moisture content. The rest of the samples were sliced, oven dried in a cabinet dryer (Model F300, Chris Alex Engineering, Ibadan, Nig.) at 105 ^0C for 35 minutes, milled and stored in a Ziploc bag at room temperature for other analyses.

Determination of pH

The pH of the brine was determined by potentiometric method (AOAC, 2005) using Hanna instrument (HI 2209 pH/ORP Meter, USA). pH of brine was monitored every 24 h for 7 days during fermentation.

Proximate Composition

Proximate composition of the fruits including moisture, protein, lipid, crude fiber, ash contents were determined using the official method of the Association of official Analytical chemist AOAC (2005). All chemical analyses were performed in triplicates. Carbohydrate was determined by difference, 100 % – (protein +ash + fat + fiber contents). Energy in Kcal was calculated for vegetables according to Asibey-Berko and Taiye (1999), (2.44 Kcal, 2.57 Kcal and 8.37 Kcal), for protein, carbohydrate and fat respectively. Mineral content was determined according to (AOAC, 2005). The elements, calcium (Ca), magnesium (Mg) and copper (Cu) were determined using Atomic Absorption Spectrometer (PG 990, United Kingdom) at wavelength of 422.7 nm, 285.2 nm and (324.8 nm) respectively, and sodium (Na) and potassium (K) were determined by flame photometry method using a flame photometer (Jenway PFP7, United Kingdom) at wavelength of 589.0nm and 766.4nm respectively.

Determination of Phytochemicals

Vitamin C (Ascorbic acid) was determined according to AOAC (2005) method. Saponin was quantitated according to (Price *et al.,* 2006) and tannin was estimated according to the procedure of (Makkar *et al*., 1993).

Sensory Analysis

Sensory evaluation of the (control) un-pickled, pickled with sugar and pickled without sugar samples were carried out immediately following the pickling process by un-trained panel of 15 individuals. The Garden egg samples were coded and presented randomly to the panelists. Although the panelists were untrained prior to testing, they were familiar with the fruit and instructed to score the samples on a 5-point Hedonic scale, where 1 = dislike extremely, 2 = dislike moderately, 3 = neither like nor dislike, 4 = like moderately and 5 = like extremely (Meilgaard *et al*., 1991), based on the attributes such as colour, aroma, taste, crunchiness and overall acceptability. Water and crackers were provided to cleanse palate in between sampling.

Statistical Analysis

Data from proximate, phytochemicals, minerals and sensory analysis were analyzed using descriptive statistics, Analysis of variance (ANOVA) with a post-hoc Duncan New Multiple Range Test in IBM SPSS Statistics 23.0 version at ($p<0.05$) significant level.

RESULTS AND DISCUSSION

Acidity

The pH values of brine without sugar were lower than the sample with sugar throughout the pickling period. Values for brine without sugar ranged from (1.95±0.01 to 2.81±0.03), compared to brine with sugar (2.45±0.06 to 3.33±0.01), possibly due to osmotic dehydration. According to Yadav and Singh (2014), osmotic dehydration increase uptake in sugars and removes acid in fruits and vegetables during pickling. All the pH values increased during the period of pickling as presented in Figure 1. High acid range food confers more antimicrobial effects on contaminating organisms, by inhibiting microbial activity as reported by Medina *et al* (2015). The pH values obtain from pickled garden egg in this study are lower than 4.0. Vinegar is so useful at preserving food, because it is an acid that is safe to consume and it inhibits the growth of pathogenic and spoilage microorganisms (Entani *et al.*, 1998).

Nutrient content of pickled garden egg

The nutritional compositions of pickled and unpickled garden eggs on dry weight basis are presented in Table 1. The moisture content of the garden egg samples ranged from (1.11 to 1.12 %). Protein content ranged from (13.8 to 19.5 %). Crude fiber content ranged from (8.5 to 15.8 %). Fermentation or pickling of foods increases the availability of nutrients, making digestible and indigestible constituents readily utilizable (Evans *et al.*, 2013). Therefore, pickled garden egg had higher fiber content compared to unpickled garden egg. Fat content of garden egg samples in this study ranged from (2.17 to 5.4 %) and ash content ranged from (12.7 to 18.0 %). The unpickled sample had the lowest values in protein and fibre, and statistically ($p<0.05$) different compared to the pickled samples. Protein content of (13.8 %) is within range of (12.43 %) reported by Ifon and Bassir (1980). The protein content of pickled garden egg sample was higher than the unpickled sample, because fermentation increases the nutrients, providing nutritious and palatable foods (Okorie and Okaka, 2017). According to Pearson (1976), vegetables that provide more than 12% of its calorie value from protein are good source of protein. Fat content of (1.65 %) reported by Agoreyo *et al* (2012) for S*olanum melongena* specie is within range observed in the pickled samples. Furthermore, it has been documented that most fruits and vegetables are low in crude fat content (Aliyu, 2006). Also, garden egg has no cholesterol and is virtually low in fat. In view of the low-fat content recorded in this study, garden egg can be consumed by a wide range of people including adults, elderly and children and can also serve as a weight restricted diet (Eze and Kanu, 2014). The unpickled sample had the least fiber content and significantly different ($p\leq0.05$) to the pickled samples. Garden eggs are valuable source of dietary fiber. The crude fiber content obtained in this study was within range of (3.90 – 6.22 %) reported by Auta and Ali (2011) for S*olanum incanum*. Also, high fiber content in the garden egg helps in reducing cholesterol level in the human body, protecting the heart in the process (Eze and Kanu, 2014). Unpickled garden egg had the highest ash content of (18.0 %), the pickled sample with sugar had (12.7 %), and was observed to have the least value. This could be as a result of leaching of soluble inorganic salt from the fruit during pickling (Aluge *et al.*, 2016). The ash content obtained in this study was within range (15 %) reported by Eze and Kanu (2014) but contradicts the value (1.96 %) obtained by Agoreyo *et al* (2012). There was significant difference between the samples at ($p\leq0.05$). The overall carbohydrates content ranged from (45.1 to 54.3 %). Garden egg pickled in salt had the lowest carbohydrates content, while the unpickled garden egg had (54.3 %).

Carbohydrate reduction in the pickled samples could be the result of microbial activities/growth involved in pickling (Akinola and Osundahunsi, 2017). Available carbohydrates content was comparable to (51.74 %) reported by Auta and Ali (2011) but contradicts (6.01 %) reported by Aliyu (2006).

Mineral composition of fermented and unfermented garden egg samples

The results of the mineral contents are presented in Table 2. Calcium content ranged from ($105.6^{c} \pm 0.02$ to $207.3^{a} \pm 0.01$ mg/g). The pickled sample had the highest calcium content of (207.263 mg/g). Sodium content ranged from ($315.4^{c} \pm 0.01$ to $346.2^{a} \pm 0.01$ mg/g). Magnesium ranged from ($162.3^{c} \pm 0.02$ to $194.5^{a} \pm 0.01$ mg/g). It was observed that magnesium content of the pickled samples was lower than the raw sample, possibly because magnesium availability is essential for microbial cell growth (Walker, 1994). Copper ranged from ($67.9^{c} \pm 0.01$ to $747.1^{a} \pm 0.01$ mg/g). The calcium content obtained in this study for unpickled garden egg was (105.6 mg/g) which contradicts (15.29 mg/g) obtained by Auta and Ali (2011). Potassium content of (183.0 to 183.7 mg/g) is within the range of *Solanum incanum* (216.89 mg/g) reported by Auta and Ali (2011). Pickled sample with salt (PGESA) had the highest sodium content and significantly different. The sodium content contradicts (149.34 mg/g) reported by Auta and Ali (2011). However, Yoshimura *et al* (1991) has documented that *Solanum macrocarpon* has high level of sodium. Further increase in mineral content could be as a result of the direct addition of vinegar, as it has been documented that vinegar has at least 20 minerals including copper, magnesium, sodium, potassium (Paneque *et al.,* 2016; Fu *et al.,* 2013).

Selected phytochemical and Anti-nutritional content of garden egg

The vitamin C content of (*Solanum aethiopicum* L.) garden egg in this study ranged from (3.3 ± 0.08 to 3.4 ± 0.2 mg/100g) (Table 3). The vitamin C content of the unpickled sample is slightly higher than the pickled, but not statistically different from each other ($p<0.05$). Vitamin C values are within the range of (2.40mg/100g) reported by Offor and Igwe (2015), but lower than (6.27 mg/100g) reported by Auta and Ali (2011). Vitamin C content was found to be reduced in pickled guava fruit (Ramli and Saadon, 2021) as also observed in this study. The tannin content of garden egg ranged from ($1.93^{c} \pm 0.67$ to $2.73^{a} \pm 0.85$ mg/g) (Table 3). The samples were statistically different from each other at ($p<0.05$). The unpickled sample had the highest tannin content of (2.7 mg/g). The tannin content obtained compares favorably with (2.45 mg/g) tannin reported by Auta and Ali (2011). The bitter property of S*olanum macrocarpon* is due to the presence of tannin according to Ekop *et al (*2005). Similar trend was observed with the saponin content of garden egg as the unpickled raw sample had the highest saponin content of ($11.58^{a} \pm 0.1$ mg/g). The saponin content observed is lower than (14.40 mg/g) reported by (Auta, 2008). Numerous processing such as pickling/fermenting and cooking methods have been shown to possibly reduce the amount of these antinutrients and hence their adverse effects (Swain *et al.,* 2014).

Sensory Evaluation

Figure 2 shows the results of the sensory analysis of the samples. Colour ranged from (2.7 to 3.5); aroma ranged from (2.6 to 3.7); taste ranged from (2.3 to 3.7); crunchiness ranged from (2.8 to 3.7) and general acceptability ranged from (2.5 to 3.7). There were significant differences ($p<0.05$) between samples UPRGE, PGESU

and PGESA using Duncan's Multiple Range Test. It was observed in this study that panelists consistently scored unpickled garden egg higher in all the sensory attributes analyzed, probably because it is more familiar to them than pickled garden egg. Between the pickled samples, the garden egg pickled with sugar received the second highest score. Apple vinegar may have negatively impacted these sensory qualities. Furthermore, pickling of fruits and vegetables is not common in this society and consumption of pickled foods may require acquired taste. Further, spices may also be added for improved palatability. Pickled garden egg (*Solanum aethiopicum L.*) in brine with or without sugar is presented in Figure 3.

A Spearman *rho* correlation coefficient was calculated for the relationship between the various treatments and sensory attributes (color, aroma, taste, crunchiness, and overall acceptability) of pickled garden eggs. Correlation between color (*rho* (45) = -.346*, *p* .020); aroma (*rho (*45) = -.495**, *p* .001); taste (*rho* (45) =-.368*, *p* .013); crunchiness (*rho* (45) =-.294*, *p* .050); overall acceptability (*rho* (45) =-.457*, *p* .002) and method of treatment. All the sensory attributes analyzed were observed to have strong and significant relationship with overall acceptability of the garden eggs (Table 4). Correlation between method of treatment and nutritional composition (protein, fibre, carbohydrate and saponin) were also strong and significant (data not included).

CONCLUSION

This research has shown that the shelf life of garden egg (*Solanum aethiopicum* L.) can be extended through pickling. Pickling improves the nutritional composition of garden egg such as protein, fat and some minerals and also reduces the anti-nutritional content of the fruit. Panelist preferred the raw unpickled garden egg probably because they are not familiar with the pickled fruit. However, the pickled garden egg samples with sugar (PGESU) had the highest score than the pickled without sugar sample. For further studies, spices could be added to the pickling process so as to improve the taste and consumer sensitization of pickled garden egg is also recommended.

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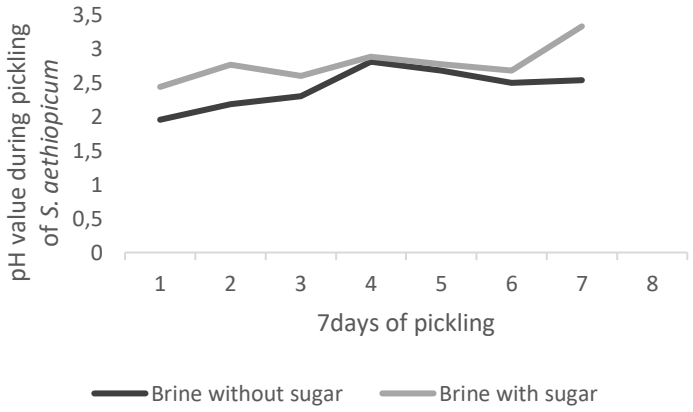

Figure 1. pH values of brine during the 7 days of pickling garden eggs

Figure 2. Sensory attributes of garden egg samples. UPRGE = Un- pickled garden egg; PGESU = Pickled with sugar; and PGESA = Pickled with salt garden eggs

Figure 3. Garden egg (*Solanum aethiopicum* L.) pickled in brine with salt or sugar.

Table 1. Proximate composition of unpickled and pickled garden egg on dry weight basis

	Proximate composition (%) *						
Sample	**Moisture**	**Protein**	**Fibre**	**Fat**	**Ash**	**CHO**	**Energy Kcal**
UPRGE	1.11±0.00[a]	13.8±2.10[b]	8.5±2.3[b]	5.4±2.8[a]	18.0±1.7[a]	54.3±0.7[a]	272.72
PGESU	1.11±0.00[a]	17.3±3.4[ab]	14.8±1.4[a]	2.7±2.4[a]	12.7±1.3[b]	52.6±1.9[a]	252.59
PGESA	1.12±0.01[a]	19.5±1.7[a]	15.8±1.1[a]	2.7±1.3[a]	17.1±3.1[a]	45.1±3.8[b]	231.19

*Values in means of triplicate determination ±SD. Mean with the same superscript in the same column are not significantly different ($p<0.05$). UPRGE = Un-pickled raw Garden egg; PGESU = Pickled Garden egg with sugar; PGESA = Pickled Garden egg with salt.

Table 2. Mineral content (mg/g) of unpickled and pickled garden egg samples

Sample	**Calcium**	**Potassium**	**Sodium**	**Magnesium**	**Copper**
UPRGE	105.6±0.02[c]	ND	315.4± 0.01[c]	194.5± 0.01[a]	67.9± 0.01[c]
PGESU	207.3±0.01[a]	183.0±0.01 [a]	332.2±0.01[b]	186.4±0.01[b]	747.1±0.01[a]
PGESA	153.9±0.01[b]	183.7±0.01 [a]	346.2±0.01[a]	162.3±0.02[c]	511.6±0.01[b]

*Values in means of duplicate determination ±SD. Mean with the same superscript in the same column are not significantly different ($p<0.05$). UPRGE = Not pickled raw Garden egg; PGESU = Pickled Garden egg with sugar; PGESA = Pickled Garden egg with salt; ND=Not determined.

Table 3. Phytochemical Content (mg/g) of garden egg

Sample	**Vitamin C**	**Tannin**	**Saponin**
UPRGE	3.37 ±0.21[a]	2.73 ±0.01[a]	11.58 ± 0.01[a]
PGESU	3.22 ±0.08[a]	1.93 ± 0.01[c]	11.06 ±0.01[b]
PGESA	3.27 ±0.41[a]	2.34 ±0.01[b]	10.75 ± 0.01[c]

*Values in means of triplicate determination ±SD. Mean with the same superscript in the same row are not significantly different ($p<0.05$). UPRGE = Unpickled raw Garden egg; PGESU = Pickled Garden egg with sugar; PGESA = Pickled Garden egg with salt.

Table 4. Spearman Correlation between method of treatment and sensory of pickled garden egg

	Colour	Aroma	Taste	Crunchiness	Overall Acceptability
Treatment	ρ(45)=-.346* p<0.020	ρ(45)=-.495** p<0.001	ρ(45)=-.368* p<0.013	ρ(45)=-.294* p<0.050	ρ(45)=-.457* p<0.002
Colour		ρ(45)=.514** p<0.000	ρ(45)=.570** p<0.000	ρ(45)=.434** p<0.003	ρ(45)=.590** p<0.000
Aroma			ρ(45)=.562** p<0.000	ρ(45)=.582** p<0.000	ρ(45)=.595** p<0.000
Taste				ρ(45)=.635** p<0.000	ρ(45)=.682** p<0.000
Crunchiness					ρ(45)=.695** p<0.000

*Correlation is significant at the 0.05 level (2-tailed); ** Correlation at the 0.01 level (2-tailed)