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Effects of Salt Treatment and Drying Methods on the Proximate, Vitamin and Chlorophyll Content of Okra Fruit (*Abelmoschusesculentus*) Slices.

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Abstract

This study evaluated effects of salt treatment and three drying methods {(solar (dehytray^{tm})}, hot air oven, and local sun drying) on nutrient compositions of okra slices. Specifically, the study determined effects of salt treatment and three drying methods on the following attributes of okra slics: proximate composition; vitamin composition and chlorophyll content. Okra used for this study was purchased from Abakpa main market Abakaliki. Fresh okra (600g) was thoroughly washed, drained and divided into two portions of 300g each. One portion was given salt treatment, the other was not treated. The okra was sliced and samples were dried using the three drying methods. The proximate, vitamin and chlorophyll content of the samples were evaluated using standard methods. The proximate composition results revealed that fat, moisture, ash, protein, fibre and carbohydrates content varied from 1.30-2.25, 10.00-81.55, 1.04-18.75, 4.82-20.60, 6.15-10.25 and 4.74-51.25% respectively. The proximate composition results show that the different drying methods used in this study significantly ($p<0.05$) improve the ash, protein, fibre and carbohydrates contents of the okra slice while reducing the moisture content. Vitamin C and E content of the samples ranged from 0.0027 - 0.0061 mg/100g and 45 to 88.05 mg/100g. The different drying methods reduced the vitamin C and E content of the okra slice. The values of chlorophyll-a, chlorophyll-b and total chlorophyll ranged between 0.015 to 0.287, 0.063 to 0.570 and 0.048 to 0867 mg/100g respectively. The findings of this study show that drying increased the nutrient content and may be helpful in effectively preserving *Abelmoschusesculentus* and ensuring its availability throughout the year. Based on findings, four recommendations were made.

Keyword: Okra, Drying, Salt, Treatment, Proximate, Vitamin, Chlorophyll

Introduction

Okra (*Abelmoschusesculentus L. Moench*), also known as lady's finger, is a member of the Malvaceae family (Dantas*et al.,* 2021; Durazzo*et al.,* 2019). It's an edible vegetable that is primarily grown in Africa, North, and South China (Agregan*et al.,* 2022). It is one of the most significant vegetables, extensively cultivated in Nigeria and all over the world for its soft fruits and young leaves.It is very suitable to be grown in subtropical, tropical, and warmer areas of the temperate regions (Alabi*et al.,* 2023; Ume *et al.,* 2018).It contains a variety of potent ingredients, including flavonoids, polysaccharides, pectin, trace minerals, vitamins, and proteins (Wang et al. 2018). Okra has a huge commercial market because of its great nutritional content and inexpensive cost of cultivation. It is used in the treatment of a number of illnesses, including inflammation of the intestine, stomach, and kidneys, and is antihelmintic, antiparasitic, and emollient (Sousa et al., 2015). It can be used to make gluten-free baked products by thickening, adhering, and emulsifying gluten-free flours (Gemede et al., 2018; Liu et al., 2021). It contains significant amounts of pectin and lignin as well as being a rich source of mucilage (Kpodo*et al.,* 2017). Because of its substantial moisture levels and respiratory activity, okra is particularly perishable and hence requires a suitable method for its preservation so as to be used over an extended period of time (Falade and Omojola, 2010; Xiao *et al.,* 2018). On the other hand, okra losses are relatively substantial as a result of inadequate post-harvest management. Nigeria is one of the world's top producers of okra fruits, producing 15,000 tons per hectare each year (Anastasia *et al.,* 2021). Even though okra is only used for cooking domestic dishes, the increased okra fruit cultivation in Nigeria typically results in yearly post-harvest losses. Any seed not used for replantation is thrown out during a production glut, which results in significant post-harvest losses (Anastasia *et al.,* 2021). Therefore, the goal of the drying is to increase the shelf life of crops by lowering cellular water activity and reducing their initial volumes so that distribution and storage expenses can be reduced (Ricce et al., 2016).

Okra is preserved traditionally by slicing and sun drying. Several problems affect this process, such as the lack of pre-treatment before drying, direct exposure of the product to sunlight, dust, dirt, insects, and other contamination, and a slow rate of drying, which compromises the finished product's nutritional value. These restrictions can cause the quality of the end products to decline, sometimes to the point where they are no longer edible. Therefore, utilizing advanced methods of drying to dry the okra is an efficient way to solve these problems (Baeghbali, et al., 2020).

Oven or solar dryer (dehytray^{tm}) can solve all of these problems. To achieve the "safe storage time period" during which the quality of the products is unaffected by any microbial growth, products must be dried using solar energy until they reach a safe moisture content of about 8–10% (wet basis) (Shimpy and Anil, 2023). Modern drying techniques minimize food losses and boost product quality. Many thermal applications now use solar energy as a replacement. The drying industry accounts for the majority of energy use in developing nations, both conventional and unconventional. The numerous problems associated with open-air drying and industrial drying are eliminated when solar dryers are used for drying applications (Ekka and Kumar, 2023).

Drying refers to the process of vaporizing and evaporating water in food under natural or artificial conditions (Xiao *et al.,* 2018). It is one of the most popular and straightforward methods of preserving food and has been shown to improve the shelf-life of foods. Foods are primarily dried to reduce moisture content to a level that permits safe long-term storage (Ibeogu and Eze, 2022). Drying is extremely important as it makes products available all year round and avoid post-harvest losses (Ibeogu and Eze, 2022). The usefulness of the new, farmer-friendly solar driers, such solar (dehytray^{tm}) for okra, has not been thoroughly investigated and documented in the literature, though. Hence, this study will be of beneficial to local farmers, food processor and the populace at large with use of improved sun-drying method and also to produce premium food free from contamination that can improve health or well-being of the populace.

Objective of Study

This study was to evaluate the effects of salt treatment and three drying methods {(solar (dehytray^{tm})}, hot air oven, and local sun drying) on nutrient compositions of okra slices. Specifically, the study determined effects of salt treatment and three drying methods on the following attributes of okra slice:

1. proximate composition
2. vitamin composition.
3. chlorophyll content

Materials and Methods

Design of study: It was an experimental design.

Procurement of materials: Matured okra fruits were purchased from Abakpa main market in Abakaliki, Ebonyi State Metropolis, and taken to the Department of Food Science and Technology, Ebonyi State University, Abakaliki, for further processing.

Sample preparations/ drying treatments: The fresh okra was sorted and washed several times with water to remove dirt and left to drain. Six hundred (600) g of the cleaned okra sample was divided into two equal portions (300 g each). The first portion (300g) given salt treatment by washing it was wash with a 50 g/L salt solution. While the second portion was not treated with salt solution. The okra was sliced with a sharp, sterilized knife to a 2.0 mm thickness.

The samples were dried as follows:

Solar drying: A portion weighing 100 g from both treated and 100g untreated okra was loaded into a solar dryer (dehytray^{tm}). Thereafter, which, the okra was spread on a tray and covered with the glass slide. The solar dryer (dehytray^{tm}) was taken outside in the sun, where it was placed on top of a stool. The drying started in the morning and continued till the sample was fully dried.

Local sun drying: Second set of both salt treated (100g) and untreated (100g) sliced okra was spread on two different local mats and was taken inside at sunset and packaged when fully dried.

Oven drying: Third set, salt treated (100g) and untreated (100g) were subjected to oevn drying. The oven was pre-heated to a temperature of 60 °C, which was regulated by a thermostat while the samples were being prepared to ensure the stability of the condition of the drying chamber. After arranging the trays in the dryer, the fan was switched on and set to 0.5 m/s using the fan regulator, with the speed measured with the anemometer. After that, 100g of the sample was also transferred to the oven and dried. The dried okra was then packed in a plastic container for further analysis.

Proximate Analysis: Proximate composition of moisture, crude protein, ash, and crude fat of the dried okra samples were determined according to Association of Official Analytical Chemical (AOAC), (2012). In order to calculate protein, total nitrogen was converted using a conversion factor of 6.25. By deducting the percentages of moisture, ash, protein, and fats derived from 100, the percentage of total carbohydrate content of the okra seed flour sample was determined.

***Total Chlorophyll Content*:** The chlorophyll content of okra was determined according to the method found in the report of Xiao *et al.* (2018) and expressed as mg/100g dry weight.

Determination of Ascorbic Acid (Vitamin C): The method as described by the AOAC, (2012) was used to determine Vitamin C content. This method was based on the reduction of the dye (2, 6 dichlorophenolindophenol) by an acid solution of ascorbic acid.

Determination of Vitamin E: Vitamin E content of the samples was determining according to the method describe by (AOAC, 2010) official titrimetric method.

***Data analysis*:** Data obtained was subjected to analysis of Variance (ANOVA). Means were compared using Duncan multiple comparison test. Difference between means was accepted at P<0.05.

Results

Table 1: Effect of salt treatment and drying methods on Proximate Composition (%) of okra slices

Okra samples	Vitamin C (mg/100g)	Vitamin E (mg/100g)	Chlorophyll-a (mg/100g)	Chlorophyll-b (mg/100g)	Total chlorophyll-a (mg/100g)
Treated fresh	0.0053^{b} ± 0.0003	88.05^{a} ± 0.919	0.242^{b} ± 0.031	0.415^{b} ±0.035	0.727^{b} ± 0.033
Untreated fresh	0.0061^{a} ± 0.0001	81.90^{b}± 0.990	0.287^{a}± 0.018	0.570^{a}± 0.042	0.867^{a}± 0.094
Treated oven	0.0032^{c}± 0.0001	48. 74^{g}± 0.035	0.108^{c}± 0.001	0.179^{cd}± 0.001	0.286^{c}± 0.002
Untreated oven	0.0036^{d}± 0.000	45.00^{c}± 0.035	0.110^{c}± 0.001	0.187^{c}± 0.002	0.296^{c}± 0.001
Treated solar	0.0030^{de}± 0.000	74.20^{c}± 0.042	0.059^{d} ± 0.001	0.139^{de}± 0.001	0.149^{d}± 0.068
Untreated solar	0.0045^{c}± 0.0007	71.95^{d}± 0.035	0.015^{e}± 0.001	0.063^{f} ± 0.001	0.149^{d}± 0.001
Treated sun	0.0027^{e}±0.0002	68.70^{e}± 0.042	0.016^{e}± 0.001	0.063^{f}± 0.001	0.049^{d}± 0.002
Untreated sun	0.0034^{de}±0.0002	61.50^{f}± 0.035	0.029^{e}± 0.001	0.107^{ef}± 0.001	0.048^{d}± 0.002

The values are means± standard deviation of duplicate measurements. Means bearing similar superscript within the same column are not significantly different (p>0.05).

Table 1 shows the effect of salt treatment and drying methods on the proximate composition of okra fruit. The salt treatment and the different drying methods employed significantly decreased the moisture content of the sample. The carbohydrate, protein, fiber, and ash content of the sample increased with the different drying methods and salt treatments employed in this study.

Table 2: Effect of salt treatment and drying methods on Vitamin and Chlorophyll content of okra slices

Okra samples	Vitamin C (mg/100g)	Vitamin E (mg/100g)	Chlorophyll-a (mg/100g)	Chlorophyll-b (mg/100g)	Total chlorophyll-a (mg/100g)
Treated fresh	0.0053^{b} ± 0.0003	88.05^{a} ± 0.919	0.242^{b} ± 0.031	0.415^{b} ±0.035	0.727^{b} ± 0.033
Untreated fresh	0.0061^{a} ± 0.0001	81.90^{b}± 0.990	0.287^{a}± 0.018	0.570^{a}± 0.042	0.867^{a}± 0.094
Treated oven	0.0032^{c}± 0.0001	48. 74^{g}± 0.035	0.108^{c}± 0.001	0.179^{cd}± 0.001	0.286^{c}± 0.002
Untreated oven	0.0036^{d}± 0.000	45.00^{c}± 0.035	0.110^{c}± 0.001	0.187^{c}± 0.002	0.296^{c}± 0.001
Treated solar	0.0030^{de}± 0.000	74.20^{c}± 0.042	0.059^{d} ± 0.001	0.139^{de}± 0.001	0.149^{d}± 0.068
Untreated solar	0.0045^{c}± 0.0007	71.95^{d}± 0.035	0.015^{e}± 0.001	0.063^{f} ± 0.001	0.149^{d}± 0.001
Treated sun	0.0027^{e}±0.0002	68.70^{e}± 0.042	0.016^{e}± 0.001	0.063^{f}± 0.001	0.049^{d}± 0.002
Untreated sun	0.0034^{de}±0.0002	61.50^{f}± 0.035	0.029^{e}± 0.001	0.107^{ef}± 0.001	0.048^{d}± 0.002

The values are means± standard deviation of duplicate measurements. Means bearing similar superscript within the same column are not significantly different (p>0.05).

Table 2 shows the effect of drying methods and salt treatment on the vitamin and chlorophyll content of okra slices. The Vitamin C content of the samples varied from 0.0027 mg/100g for treated sun-dried to 0.0061 mg/100g for untreated fresh. The salt treatment and the different drying methods decreased the vitamin C content of the okra. The vitamin E content of the sample varied from 45.00 mg/100 g of untreated oven-dried to 88.05 mg/100 g of treated fresh. The chlorophyll content of the okra slices for Chlorophyll-a, b, and Total chlorophyll-a varied from0.015 for untreated solar to 0.287 mg/100g for untreated fresh, 0.063 for both untreated solar and treated sun to 0.570 mg/100g for untreated fresh, and 0.048 for untreated sun to 0.867 mg/100 g for untreated fresh.

Discussion

As shown in Table 1, the fat content of the samples ranged from 1.30 to 2.25%. The lowest fat content was observed in the treated oven and treated solar dryer while the highest value was observed in the treated sun dried sample. There were significant differences ($p<0.05$) in the fat content of the okra samples dried with different drying methods. The treated sun dried sample had significantly higher fat contents than others. Also, salt treatment caused a decrease in fat content of both fresh and dried okra samples except for the sun-dried sample. The results showed that sun drying followed by solar drying best retained the fat content of okra while oven drying had the least effect on the fat content of the okra. Similar findings were made by Etaware and Etaware (2019), who found that sun drying okra boosted its crude fat content more than oven drying. Results of the present study also showed that the treatment improve the fat content of the mat dried okra slice. Fats are essential for maintaining healthy cell membranes, insulating internal organs, regulating body temperature, and preserving the appearance of hair and skin (Robert, 2010).

The three drying methods significantly ($p<0.05$) decreased the moisture content of the fresh okra. The moisture contents ranged from 10.00 to 81.55% (Table 1). The lowest moisture content was observed in the treated solar dried sample while the highest value was observed in the treated fresh okra sample. The shelf life of a food product is greatly influenced by its moisture content. Foods that contain less moisture typically have a longer shelf life (Agomuo*et al.,* 2022). Results showed that the salt treatment reduced moisture loss during sun and oven drying but not in solar drying method because the moisture content of the untreated solar sample was higher than that of the treated solar sample. This could be as a result of the presence of salt increasing viscosity, which could have created an extra barrier for mass transmission through the okra Shyam (2006). But are in contrast with the results of Oboh and Madojemu (2016) who reported a decrease in moisture content of salt treated fresh *Talinumtriangulare* leaves. Results showed that the salt treatment reduced the efficiency of drying okra using oven and sun drying methods but was enhanced using solar tray drying method, although these effects were not significant ($p>0.05$). According to reports, drying is a useful strategy for lowering moisture content, which preserves food and prevents microbial contamination (Zerihun*et al.,* 2020).

Ash contents as shown in Table 1 ranged from 1.04 to 18.75%. The lowest ash content was observed in the untreated fresh sample while the highest value was observed in the treated oven-dried okra sample. Ash content significantly ($p<0.05$) increased after drying with the three drying methods. This is consistent with the findings of Eze and Akubor (2012) for blanched oven-dried and blanched sun-dried okra, as well as the findings of Etaware and Etaware (2019) for oven-dried and sun-dried okra, all of which showed that drying increased the samples' ash contents. Oven drying caused the greatest increase followed by sun drying and solar dryer. The salt treatment increased the ash content in both fresh and dried okra sample although the increase was not significant ($p>0.05$). Similar findings were reported by Oboh&Madojemu (2016), who noted an increase in the ash content of fresh *Talinumtriangulare* leaves that had been treated with salt and vinegar. As ash content is a measure of mineral content, which may have increased due to the addition of salt, the increase in ash content is envisaged. The results showed that salting is necessary to improve the mineral content of both fresh and dried okra. Ash content is an indicator of a food's overall mineral composition (Ibeogu and Eze, 2022).

Protein contents ranged from 4.82 to 20.60% (Table 1). There were significant differences ($p<0.05$) among the values. The lowest protein content was observed in the treated fresh sample while the highest value was observed in the treated oven-dried okra sample. Protein content was increased by the three drying methods used. This is consistent with the findings of Etaware and Etaware (2019), who observed that protein content of oven-dried and sun-dried samples significantly increased when compared to fresh samples. However, the findings were in accordance with those of Dos-Santos et al. (2019), who showed a reduction in the protein content of okra dried by convective drying and lyophilization at varying temperatures. Oven drying recorded the greatest increase followed by sun drying and solar drying. Salting decreased protein content in the fresh sample. On the other hand, salting significantly ($p<0.05$) increased the protein content of all the dried samples except for sun dried sample where the increase was not significant ($p>0.05$). This study shows that salt treatment is necessary to both preserve and improve the protein content of dried okra.

Fibre contents ranged from 6.15 to 10.25%. There were significant differences ($p<0.05$) in the fibre values of the samples. The lowest fibre content was observed in the treated fresh sample while the highest value was recorded in the treated sun sample. Compared to fresh okra sample, fibre content increased after drying with the three different drying methods. In contrast, Oboh and Madojemu (2016) found that drying reduced the amount of fiber in fresh *Talinumtriangulare* leaves that had been treated with vinegar and brine. Sun drying best retained the fibre content of the fresh okra followed by oven drying and solar drying. However, the effects of the treatment on the fibre contents of the samples were not significant ($p>0.05$). Therefore, it can be said that the treatment was not a necessary pre-treatment for preserving the fibre content of okra. Increased in fibre content of the dried vegetable could be linked to loss of moisture. Hence, vegetables are good sources of fibre.

Fiber cleanses the digestive tract and stops the body from absorbing too much cholesterol. Fiber also gives dietary bulk and prevents overeating of starchy foods, which protects against metabolic diseases like hypertension and diabetes mellitus (Agomuo*et al.,* 2022; Akubugwo*et al.,* 2007).

Carbohydrate contents ranged from 4.74 to 51.25%. Significant differences (p<0.05) were observed among the values. The lowest value was observed in the treated fresh sample while the highest value was observed in the untreated solar dried sample. The carbohydrate contents of the dried samples increased significantly (p<0.05) when compare with those of the fresh samples. This is consistent with the findings of Etaware and Etaware (2019), which demonstrated that the samples of oven-dried and sun-dried okra contained higher quantities of carbohydrates than the sample of fresh okra. The highest increase in carbohydrate content was observed in solar dried samples, followed by sun dried samples and oven dried samples. The treatment had no significant (p>0.05) effect on the carbohydrate content of both fresh and dried okra samples.

The vitamin C content of the samples as shown in Table 2 ranged from 0.0027 to 0.0061 mg/100g. The lowest value was observed in the treated sun-dried sample while the highest value was observed in the untreated fresh sample and there was significant difference (p<0.05) among the samples. Drying significantly (p<0.05) decreased the vitamin C content of the okra samples. The decrease in vitamin C after the drying may be due to degradation of some compounds, as vitamin C is a heat-labile molecule (Oboh and Madojemu, 2016). There are numerous reports in the literature of vegetable vitamin C content being destroyed by heat (Shyam, 2006; Eze and Akubor, 2012; Oboh and Madojemu, 2016). Solar drying best retained vitamin C, followed by oven drying and lastly sun drying. Salting caused a decrease in vitamin C contents of both fresh and dried samples. It is also in line with Oboh and Madojemu (2016) research on *Talinumtriangulare* leaves that have been extensively salted and lightly brined with vinegar. Okra plants contain vitamin C, is good for the immune system and is essential in battling colds and viruses (Isack*et al.,* 2013).

The vitamin E content of the samples ranged from 45 to 88.05 mg/100g. The lowest value was observed in the untreated oven-dried sample while the highest value was observed in the treated fresh sample. The values were all significantly (p<0.05) different. Drying significantly (p<0.05) decreased the vitamin E content of the okra samples. Among the dried samples, solar dried samples had the highest vitamin E, followed by sun dried samples and oven dried samples.

According to Huang and Zhang (2015), drying method has an important impact on degradation of chlorophyll during drying, resulting in color changes in final product. This is exactly the case in this present study where the three drying methods employed significantly (p<0.05) decreased the chlorophyll (Chlorophyll-a, chlorophyll-b and total chlorophyll) contents of okra. This is consistent with the findings of Dos-Santos et al. (2019), who observed a marked reduction in the chlorophyll levels of okra dried by convective drying and lyophilization at various temperatures. The values ranged from 0.015 to 0.287, 0.063 to 0.570 and 0.048 to

0867 mg/kg for chlorophyll-a, chlorophyll-b and total chlorophyll respectively. The highest values were observed in the untreated fresh samples. The lowest values of chlorophyll-aand chlorophyll-b were observed in the solar dried samples while the lowest total chlorophyll was observed in the sun-dried samples. Oven drying best retained chlorophyll-a, chlorophyll-b and total chlorophyll of the okra while sun drying had the most destructive effect on the chlorophyll contents of the samples. Salting significantly ($p<0.05$) decreased the chlorophyll contents of the fresh okra and dried okra except the solar dried samples where an increase in Chlorophyll-a and chlorophyll-b were observed. The results showed that salting did improve the chlorophyll attribute of the dried okra.

Conclusion

The findings of this work show that the drying methods and the salt treatment had varying effects on the proximate, vitamin and chlorophyll content of the okra slice. The moisture content of the okra slice reduced significantly ($p<0.05$) with the salt treatment and the drying methods used. The drying process significantly ($p<0.05$) enhanced carbohydrates, ash, protein and fibre content of the okra slice but decreased the vitamin and chlorophyll content. Okra (*Abelmoschusesculentus)* could be preserved more hygienically and kept available all year round with the help of the advanced drying methods and salt treatment used in this study.

Recommendations

Based on this study the following recommendations were made:

1. Food industries and food scientists should make use of this modern technology in preserving and extending the shelf life of okra.
2. Consumers should be enlightened and encourage by food processors on the utilization of this modern technology as it has been proven to be effective in the preservation of this product.
3. The government and other non-governmental agencies should also assist local farmers through grant or loan to procure and utilize this modern equipment in drying okra samples.
4. Extension services can also be employed by the government or other agencies to convey recent advances, innovations, and new research findings as suchto local farmers.

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