



EFFECT OF DIFFERENT DRYING METHODS ON THE NUTRITIONAL AND SENSORY ATTRIBUTES OF *ABELMOSCHUS ESCULENTUS* (OKRA)

Agomuo, Jude Kelechi, Nasiru, Bilkisu Umar, *Ifeka, Calista Oluebubechukwu

Department of Food Science and Technology, Faculty of Renewable Natural and Resources, Federal University Dutsin-Ma, Katsina State, Nigeria

*Corresponding authors' email: c.ifeka@fudutsinma.edu.ng

ABSTRACT

This work was carried out to study the effect of different drying methods (shade, oven and sun drying) on the nutritional and sensory properties of *Abelmoschus esculentus* (okra vegetable). Results from this study showed that the carbohydrate content ranged from 11.64% in sample A to 54.20% in sample D, an increase due to the removal of moisture. The crude fat ranged from 0.52% to 3.40%. The ash content was markedly enhanced by drying too and it ranged from 1.30% in fresh sample to 8.91% in shade-dried sample, the fibre content ranged from 1.12% in fresh sample to 16.43% in sun-dried sample. A slight decrease in mineral content was observed upon drying except sodium and magnesium which was found to be significantly higher in the fresh sample. There were increase in phosphorous and potassium upon drying. The vitamin content showed significant difference ($p < 0.05$) in the level of vitamin C, it ranged from 3.68 mg/kg to 1.41 mg/kg, the fresh sample ranked higher followed by shade, oven and sun-dried samples. The result for sensory quality attributes showed significance difference ($p < 0.05$) in all the attributes of the okra soup made from the samples and shade dried sample gave the best result in terms of colour and taste which maybe low temperature processing that retained its sensory qualities. The result of this study suggests that drying improved the concentration of nutrients and could be useful in preserving *Abelmoschus esculentus* in a good way and ensure its availability all year round.

Keywords: okra, drying, proximate composition, mineral content, vitamin content

INTRODUCTION

Okra (*Abelmoschus esculentus*) is an economically important vegetable crop grown in tropical and sub-tropical corridor of the world. This crop is suitable for gardening as well as on large marketable granges. Okra (*Abelmoschus esculentus*) is one of similar flowering crops in the mallow family (*Malvaceae*), traced to tropical and sub-tropical Africa and is used for food (NRC, 2006). Recently, Okra is classified under the genus *Abelmoschus* instead of the formerly considered species of hibiscus.

In Nigeria, okra is cultivated in both the wet and dry seasons, however, much profit is made during the dry season when the demand is higher than supply. Fresh okra fruits are used as vegetables while the roots and stems are used for preparing "gur" or brown sugar (Chauhan, 1972), vegetable oil can also be derived from okra seeds (Farinde, Owolarafe & Ogungbemi, 2007). Freshly gathered okra has veritably high humidity content (88-90 wet basis) with safe humidity content for preservation (10 wet basis) (Shivharee *et al.*, 2000). The traditional system for conserving okra involves slicing and sun drying of the fruits until they come brittle (Kolawole and Bukola, 2010). It is very perishable because of its high humidity content and respiratory conditioning (Bakre & Jaiyeola, 2009) therefore, preservation of commodity is necessary.

Okra (*Abelmoschus esculentus*) also known as "ladies' fingers" is consumed as, a cooked vegetable or used as an additive for salads, soups and stews or taken as a fresh vegetable. It's a good source of dietary fibre, antioxidants, Vitamins and minerals (Olsen, 2019). Traditionally, Okra can be dried on surfaces such as the ground, racks, trays and concrete floorings as a means of preservation. Although sun drying is the most common practice used to save agrarian products in tropical and sub-tropical countries (Doymaz & Pala, 2002), this preservation technique is extremely weather-dependent and can easily be contaminated. In addition, the needed drying time can be relatively long and the final

product sensory qualities may deteriorate. Thus, an effective means of mitigating these challenges is to dry with hot air driers (Doymaz & Pala, 2002).

Fruits and vegetable products frequently contain phenolic composites which are oxidized and polymerized to form brown pigments, melanin, during drying and storehouse (Perera, 2005). Colour of agro-food products similar as fruits and vegetables were deduced from natural pigments, a variety of which change as the plant matures and ripens. The primary pigment affecting colour quality are the fat-soluble chlorophylls (green), carotenoids (yellow, orange and red), water-soluble anthocyanins (red, blue), flavonoids (yellow) and betalains (red) (Kasim&Kasim, 2015).

Drying is presumably the oldest system of food preservation and it's one of the most common processes used to ameliorate food stability (Vijaya Venkata Raman *et al.*, 2012). Drying preserves foods by removing enough humidity from food, reduces microbiological exertion, and minimizes physical and chemical changes during storage to avert decay and spoilage (Mongi *et al.*, 2004). Generally during drying, colour may change due to a number of chemical and biochemical responses. Among them, the most common is colour declination, especially carotenoids and chlorophyll and chemical oxidation of phenols and ascorbic acid. Chemical changes to carotenoids and chlorophyll colours are caused by heat and oxidation during drying. In general, longer drying times and higher drying temperature produce colour losses. Other factors which affect colour include fruit pH, acidity, fruit cultivar and heavy metal contamination (Mongi *et al.*, 2004).

Due to the increase in demand of fresh fruit and vegetables, there's a need to develop advanced styles for maintaining product quality. Loss in quality, post-harvest losses, environmental health hazard and limited shelf life are problems faced in the marketing of fresh okra in Nigeria due to its high respiratory rate and perishability value (Bakre & Jaiyeola, 2009). This research work proffers a guide on the

best practices of shade, oven and sun drying techniques of okra processing and at the same time, bettered quality, reduced post-harvest losses and also maintain sensory quality trait, hence ensure that okra is available at all seasons.

MATERIALS AND METHODS

Sources Raw Material

Matured okra fruits were purchased from Katsina Vegetable market (Kofar Marusa market) in Katsina State Metropolis, and taken to the Department of Food Science and Technology, Federal University Dutsin-Ma, Katsina State for further processing

Processing of Dried Okra

The fresh okra was sorted and washed to remove dirt and to maintain the quality of the okra over time after which it was then left to drain. The okra was then weighed and shared into three groups of 500g respectively. The first 500g of the fresh okra were washed, diced and evenly spread on a tray and left to dry in the sun for at least 7 hrs per day for four days until the vegetables became brittle and considered to be dried. Another 500g of the fresh okra were washed, diced and was later oven dried at 70°C for 3 hrs until it became properly dried. The third sample of 500g of the fresh okra was washed, diced then Shade dried at a room temperature which protect the drying vegetables from the direct sunlight and closely monitored until dried to constant weight. The dried okra was then packed in a plastic container for further analysis

Determination of the Proximate Composition

The proximate composition was determined on the edible portion of the okra for moisture, crude fibre, lipid, ash, protein and carbohydrate according to the method as described by the Association of Official Analytical Chemist (AOAC, 2012).

Determination of Ascorbic Acid (Vitamin C)

The method as described by the Association of Official Analytical Chemist (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 Mineral Content

Calcium (Ca) and Magnesium (Mg) levels was determined using Atomic Absorption Spectrophotometer (210 VGP model). Sodium (Na) and Potassium (K) levels was determined using Flame Photometric Method while Phosphorus (P) level was determined colorimetrically using Vanadomolybdate method (Kitson & Mellon, 2004).

Sensory Evaluation of Okra Soup

The fresh and dried samples of the okra was used to make a traditional soup, and 20 semi trained panelists who are conversant with the soup were selected from the Department of Food Science and Technology, Federal University Dutsin-Ma, Katsina State to determine taste, colour, aroma, texture and overall acceptability of the okra soup using a 9-point hedonic scale as described by Iwe, (2010).

Statistical Analysis

Data obtained was subjected to analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 20 software and the means were compared using Duncan multiple comparison test.

RESULTS AND DISCUSSION

Proximate Composition of Okra (*Abelmoschus Esculentus*)

Moisture

The result from Table 1 indicated that moisture content ranged from 6.76 to 80.09 %, with sample A having the highest moisture content of 80.09% because it did not undergo any drying process. Meanwhile, sample B with 8.50%, sample C had 8.64 %, and sample D had 6.76% which was the lowest. However, there was no significant difference between samples B and C while there was an observable significant difference between samples A and D ($P < 0.05$). This result is similar to that of Udofia & Obizoba, (2005). The moisture content of food product is critical in determining the shelf life of the product. Foods with lower moisture content has the tendency of having a longer shelf life. According to Udofia & Obizoba (2005), the low moisture content of *abelmoschus esculentus* would enhance its storability by avoiding mould growth and other biochemical reactions. Moisture reduction in foods generally; improve the digestibility of foods, increases concentration of nutrients and can make some nutrients more available. The moisture content of sample A was significantly higher than other samples with different drying methods.

High moisture content of fruits and vegetables promotes growth of micro-organisms, however drying or dehydration helps to inhibit autolytic enzymes. Drying has been reported to be an effective technique in reducing moisture content thereby, preserving the food and inhibiting microbial contamination (Wachap, 2005). Moisture in food determines the rate of food absorption and assimilation within the body.

Ash

The ash content of the four samples ranged from 1.30 % to 8.91 %, with sample C recording highest ash content of 8.91 % while sample A had the least ash content of 1.30 %. There was a significant difference ($p < 0.05$) in ash content between the fresh and each of the dried samples. The mineral content of a food product is determined by its ash content. High ash content in vegetables indicates high quantity of minerals in the samples (USDA, 2014).

Fat

The crude fat content indicates 0.52% for sample A, 2.30% for sample B, 3.40% for sample C and 2.25% sample D. the fat content of sample A decreased significantly when compared to other samples. This might be due to high moisture content of the sample. Fats are necessary to keep cell membranes functioning properly, to insulate body organs, keep body temperature stable and to maintain healthy skin and hair. (Robert, 2010).

Protein

Crude protein content between fresh (control) and dried samples ranged from 5.33% to 16.42%. Result in table 4.1 showed that, there was significant difference ($P < 0.05$) between all the samples. This result showed 16.42% for sample B the sun-dried sample and 14.70% for sample D the shade dried sample. Ukegbu and Okereke (2013) suggested that drying method and temperature may affect the protein content of vegetables due to higher denaturation of protein cell. More drying time leads to higher concentration of protein. In the present study shade drying took longer time to dry (5-7 days) compared to *abelmoschus esculentus* 2-4 days in sun drying.

Fibre

Results for fibre content revealed that oven dried samples had 16.34 %, shade dried samples had 16.51%, while sundried samples had 15.30% as compared to the fresh sample with 1.12 %. The fibre content was significantly higher in all the dried samples with different drying method than in the fresh sample. High fibre contents in the dried vegetable were attributed to the loss of moisture and vegetables are good sources of fibre. In addition, it is known that the loss of moisture increases nutrient density in foods with fibre inclusive. Fibre cleanses the digestive tract by removing potential carcinogens from the body and hence prevents the absorption of excess cholesterol. Fibre also adds bulk to food and reduces the intake of excess starchy food, and hence guards against metabolic conditions such as hypertension and diabetes mellitus (Adeyeye, 1999 in Akubugwo *et al.*, 2007).

Carbohydrate

The sample A had a mean carbohydrate value of 11.64% while the dried samples had mean values (50.15%, 47.84% and 54.20 %) for sample B, sample C and sample D respectively. However, values of sample A and C was significantly different ($P < 0.05$) but there was no significant difference between sample B and D. According to Ukegbu and Okereke (2013) various vegetables like African Spinach, fluted pumpkin and Okra in their fresh state had been noted to be poor source of carbohydrate. However, after drying the carbohydrate content of vegetable increased due to reduction in moisture content (Kolawole *et al.*, 2011). Carbohydrates provides energy for the body and that a high proportion of it is required in breakfast meals and weaning formulas (Butt, 2010).

Table 1: Effect of Drying Methods on Proximate Composition in *Abelmoschus Esculentus* (Okra)

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fibre (%)	Carbohydrate (%)
A	80.09±0.00 ^a	1.30±0.07 ^c	0.52±0.07 ^c	5.33±0.04 ^d	1.12±0.03 ^c	11.64±0.01 ^d
B	8.50±0.14 ^b	7.33±0.04 ^b	2.30±0.07 ^b	16.42±0.07 ^a	15.30±0.01 ^b	50.15±0.13 ^b
C	8.64±0.03 ^b	8.91±0.14 ^a	3.40±0.06 ^a	14.70±0.07 ^b	16.51±0.01 ^a	47.84±0.10 ^c
D	6.76±0.03 ^c	7.38±0.14 ^b	2.25±0.14 ^b	13.07±0.14 ^c	16.34±0.02 ^a	54.20±0.06 ^a

Values are expressed as means ± standard deviation (n =2); same column carrying different superscripts in mean values signifies significant differences ($p < 0.05$)

KEY:

Sample A = Fresh (Control)

Sample B = Sun drying

Sample C = Shade drying

Sample D = Oven drying

Mineral and Vitamin C Composition of Okra (*Abelmoschus Esculentus*)

Potassium, phosphorous, magnesium, sodium, and calcium were found to be present and in sufficient quantity in the fresh sample with little or no significant difference between it and the other dried samples (Table 2).

In this study, the concentration of Calcium in *Abelmoschus Esculentus* ranged from 1.37 to 1.43 mg/100g and that of potassium ranged from 5.82 to 6.09 mg/100g (NRC, 2006). As evidenced, Calcium and Potassium causes physiological development of bone, teeth and muscles and are both associated with vitamin D metabolism. Children, pregnant and nursing mothers require calcium containing substances for bones and teeth development. Okra can contribute meaningful amount of dietary calcium and potassium which is required for growth, maintenance of bone, teeth and muscle by eating significant quantity.

Magnesium plays a vital role in Calcium metabolism in bone. This mineral element is linked with circulatory disease such as ischemic heart disease (Nwaogu *et al.*, 2000). The result obtained showed that Magnesium ranged from 3.84 to 4.50 mg/100g with the sun drying having the lowest value. Although there was no significant difference between the dried samples with the different drying methods, the low values of dried samples revealed that the drying methods did not increase magnesium content of the vegetable.

The Phosphorus content of okra samples decreased during drying, just as reported by Oguche (2011) in various vegetables such as Spinach and Pumpkin leaves. Calcium, phosphorus and other nutrients helps to build healthy bones and teeth. Phosphorus assists in maintaining normal acid/base balance, encourage growth and it is also involved with the storage and use of energy. The result revealed that

phosphorus ranged from 8.55 to 8.89 mg/100g with shade dried samples having the highest percentage (8.89mg/100g) and the sun-dried sample having the lowest percentage of (8.55mg/100g). Nevertheless, it has been reported that the presence of phosphorus in a sample does not assure its availability, as its absorption also depends on the presence of Vitamin D (White and Broadly, 2005).

From the table below, the results obtained for sodium showed the oven dried sample had the least value of (0.83 mg/100g) while the fresh sample had higher value of 0.90 mg/100g. Sodium an essential mineral is involved in many important bodily functions such as cellular functions, fluid regulation, electrolyte balance and maintaining blood pressure. Plant based foods like vegetables have lower sodium content than animal product, such as meat and dairy product. Although there were variations, sodium intake is generally kept to less than 2-3 grams (2,000-3000mg) per day (White *et al.*, 2005).

Vitamin Content

Vitamin C content for the sample A was significantly higher than that of the other samples. This result also revealed that the three drying methods differ significantly ($p < 0.05$) in the level of Vitamin C. the shade dried sample compared to sun and oven dried samples was significantly higher this might be due to low temperature of shade drying (atmospheric temperature) as compared to high temperature of oven drying (about 70°C for 3 hours) as vitamin C can be lost with high temperature. Adejumo (2012) similarly reported that Vitamin C can easily be destroyed at high temperature because they are heat sensitive. When fruit vegetables are exposed to heat or high temperature decrease in Vitamin C could occur (Isack & Lyimo, 2013). Okra plant contain vitamin C which is beneficial for immune system and also plays an important role in fighting off colds and viruses, vitamin C also helps to decrease the risk of developing further complications like pneumonia and lung infections when taken during cold (Isack *et al.*, 2013). water loss in foods or dehydration may also induce vitamin losses as reported by Hossain *et al.*, (2001)

Table 2: Effect of Drying Methods on Minerals and vitamin C in *Abelmoschus Esculentus* (Okra)

Samples	Sodium (mg/100g)	Magnesium (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Phosphorus (mg/100g)	VitaminC (mg/100g)
A	0.90±0.06 ^a	4.50±1.41 ^a	6.02±0.14 ^b	1.43±0.42 ^a	8.82±0.28 ^a	3.68±7.04 ^a
B	0.86±0.28 ^{ab}	3.84±0.28 ^b	6.09±0.03 ^a	1.40±0.00 ^a	8.55±0.71 ^a	1.49±1.96 ^c
C	0.88±0.06 ^{ab}	4.03±0.28 ^b	5.82±0.28 ^c	1.37±0.01 ^a	8.89±0.03 ^a	2.80±1.82 ^b
D	0.83±0.42 ^b	3.98±1.41 ^b	5.99±0.00 ^b	1.42±0.14 ^a	8.70±2.83 ^a	1.41±3.11 ^d

Values are expressed as means ± standard deviation (n =2); same column carrying different superscripts in mean values signifies significant differences (p<0.05)

KEY:

Sample A = Fresh (Control)

Sample B = Sun drying

Sample C = Shade drying

Sample D = Oven drying

Sensory Evaluation

Different soups were prepared from the four samples of *Abelmoschus esculentus* such as fresh (Control), Oven, Sun and Shade dried these were analysed for the sensory attributes and are shown in Table 3. The results showed that there was a significant difference (p<0.05) in all attributes of the okra soup samples, similar observation were made by Chidan *et al.* (2012). Sample A (fresh) was the most preferred sample in terms of taste, colour, aroma, mouth feel and overall acceptability.

Colour

The result showed that the colour of the oven dried sample was significantly lower (p<0.05) (6.25) than the sun-dried sample (6.70), the lower values for colour of the soup from oven dried okra is attributed to the unattractive colour caused by the temperature used in drying the sample, as browning reaction occurs in the presence of high temperature and prolonged drying period thereby deteriorating the colour. Colour is an important parameter for the sensory perception and acceptability of food by consumer (Igbabul *et al.*, 2014). Colour also provides information on the nutrient content, the freshness of a food and the type and intensity of the processing as reported by Coultate (2009).

Aroma

Aroma is a fundamental sensory attribute which refers to the sensations in the nostrils as a result of rising of food or drink volatile compounds. Sample A which is the fresh sample had the overall highest mean value of 7.90 which was then followed by sample C was the shade dried sample (7.05) with

sample B having the least value of 6.45. There was however no significant difference (p<0.05) among all the samples. The high acceptance of sample A to the other samples could be due to its fresh nature and familiarity of consumers to it.

Mouthfeel

This shows the response of sense organs in the mouth to the roughness, smoothness, chew ability, stickiness of food in the mouth. The control being fresh okra had a mean value of 7.75, where samples B (sundried), C (shade dried), D (oven dried) had mean values of 6.60, 6.95, 6.30 respectively. There was found to be significant difference at p<0.05 between samples A and C however there was no significant difference between samples B and D. The results were as expected as samples A and C absorbed more water and had a soft palatable sensation in the mouth making it more acceptable compared to the dry gritty texture of samples B and D.

Taste

Taste is a code given to different food by the sensorial palate when the food is ingested into the mouth. The sample A had the highest mean value of 7.85. Sample C emerged as the one with highest taste quality in terms of dried samples with mean value of 7.20, while the sample B and sample D ranked the least with 7.00 and 6.70 as its mean value. There was no significant difference (p< 0.05) among the samples A and samples B and D however as there was significant difference between them and samples C.

General acceptability

The results revealed that Sample A had the highest score for general acceptability with a mean value of 7.60. Samples B and C shows no significant difference, while there was an evident significant difference between samples A and D. The result showed a decrease in the level of general acceptability and this could be attributed to the increase exposure to heat.

Table 3: Mean Scores of Soups made from *Abelmoschus Esculentus* (Okra)

Sample	Taste	Aroma	Mouth-feel	Colour	General Acceptability
A	7.85±1.14 ^a	7.90±0.72 ^a	7.75±0.97 ^a	7.55±0.60 ^a	7.60±0.82 ^a
B	7.00±1.21 ^a	6.45±1.14 ^a	6.60±1.60 ^b	6.70±1.21 ^{ab}	6.95±1.15 ^{ab}
C	7.20±0.89 ^{ab}	7.05±0.94 ^a	6.95±1.15 ^{ab}	7.05±1.10 ^b	7.05±0.75 ^b
D	6.70±1.34 ^b	6.75±1.25 ^a	6.30±1.42 ^b	6.25±1.41 ^c	6.75±1.16 ^{ab}

Values are expressed as means ± standard deviation (n =2); same column carrying different superscripts in mean values signifies significant differences (p<0.05)

KEY:

Sample A = Fresh (Control)

Sample B = Sun drying

Sample C = Shade drying

Sample D = Oven drying

CONCLUSION

This study has shown that most of the consumers in Katsina State are very familiar with the drying of okra without being aware of other drying methods and its nutritional benefits.

Also, most farmers were not conscious of other uses of okra, like medicine, fertilizer and feed for animals, apart from for human consumption. Analysis revealed that most of the drying methods significantly increased ($p < 0.05$) some of the nutrient's content such as Carbohydrate, ash content, phosphorus and potassium. Hence, the result showed that drying improved the concentration of both organic and elemental constituents of the okra. Drying methods or dehydration could be useful in preserving *Abelmoschus Esculentus* in a more hygienic way and ensure that it is available all year round.

RECOMMENDATION

This research showed that Okra could be successfully preserved by drying, hence, there is need to use other improved methods such as freeze drying to produce more quality products.

Dried Okra could be a substitute for the fresh forms to ensure that this food is available at all times. Government, Non-Governmental Organization and research institutions should put in place infrastructures to promote hygienic drying and consumption of dried fruit vegetables especially during the off-season period.

However, some improvement is needed to enhance the colour attribute so as to make it more attractive to consumers. Also, farmers should be encouraged to produce more Okra so that food scientist can preserve and develop other value-added products from fruit vegetables for diversification. More research on chemical analysis of *Abelmoschus esculentus* is necessary to explore their usefulness. Fruit vegetables are good source of vitamins and minerals therefore its consumption should be encouraged in order to solve the problem of many noncommunicable diseases such as pneumonia, diabetes and so on.

REFERENCES

A.O.A.C (2012) Official Methods of Analysis of the Association of Analytical Chemist, Washington D.C pp. 223-225

Adeyeye EI, Okotiti MKO. (1999) Proximate Composition and Some Nutritionally Valuable Mineral of Two Varieties of *Capsicum annum* L. (Bell and Cherry Peppers). *Discovery Innov*; (11): 75-85.

Agbo AC, Gnaki D, Beugre GM, Fondio L, Kougme C (2008) Maturity degree of four okra fruit *Agric. Nat res. PMB.*, 3311: 15-20.

Akintoye HA, Adebayo AG, Aina OO (2011) Growth and yield response of okra inter cropped and microbial composition of (*abelmoschus esculentus*). *Journal of Agricultural science*.

Akintoye HA, Adebayo AG, Aina OO (2011) Growth and yield response of okra intercropped with live mulches. *Asian J Agric Res.* 5: 146-153.

Akubugwo A. N. B., Obasi and S. C., Ginika. (2007) Nutritive Value of *S. Nigram* Seed and Leaves *Journal of Nutrition*, 6(4), 2007, 323-326.

Anieke U.J., Nwankwo O.G., Adinde J.O., Ukwuani C.M., Uche O.J., Agu C.J., Ugwuanyi, P.O and Ozougwu S.C. (2016) Comparative Evaluation of Some Nutrient Contents of *Moringa Oleifera* Leaves Processed under Three Different Drying Methods; Sun-drying, Air-drying and Oven-drying. *International journal of science and Nature*, 7(2):429-432.

Artfield, A.D (2005), *Vegetable Gardening in Western Nigeria*. Macmillian , pg 63. Asparagus eggplant turnips green beans carrots and cauliflower. *Food chem* 103:676-680.

Bakre LG, Jaiyeola KT (2009). Effects of drying methods on the physiochemical and compressional characteristics of Okra powder and the release properties of its metronidazole tablet formulation. *Archives of Pharmacal Research* 32:259-265

Butt, M.S and Batool, R., (2010) "Nutritional and Functional Properties of Some Promising Legumes Protein Isolates", *Pak, J. Nutr* 9(4): 373-379.

Chidan, M., Kumar, C.S., Mythily, R. and Chandraju, S. (2012) Extraction and Mass Characterization of Sugars from Ash Gourd Peels (*Bennicasa Hispida*). *Rasayan Journal of Chemistry* 5(3): 280-285. Composition of 13 wild plant foods of Niger. *J food comp* 13: 83-92.

Danso-Boating, E. (2013) Effect of Drying Methods on Nutrient Quality of Basil (*ocimum viride*) Leaves Cultivated in Ghana. *International Food Research Journal* 20(4): 1569-1573.

Doymaz & Pala, I., and Pala, M. (2002) Hot-air drying characteristics of red pepper. *Journal of Food Engineering*, 55, 331-335. doi:10.1016/S02608774(02)00110-3.

Farinde A, Owolarafe O, Ogungbemi I (2007) An overview of production, processing, marketing and utilisation of okra in egbedore local government area of Osun State, Nigeria. *Agricultural Engineering* 4: 1-17.

Food and Agricultural Organization (FAO), (2003) Handling and preservation of fruits and vegetables by combined methods for Rural Areas. *Bullentin* 149. Food and Agricultural Organization of the United Nations, Rome 2003.

George, P.M (2003). *Encyclopedia of Foods*. Washington D.C.I: P. 526.

Hossain, M.E., Alam, M.J., Hakim, M.A., Amanullah, A.S.M and Ahsanullah, A.S.M. (2010) An Assessment of Physicochemical Properties of Some Tomato Genotypes and Varieties Grown at Rangpur, *Bangladesh Research Publication Journal* 4(3): 135-243. Induced peel browning in banana. *Post-harvest biology and technology*, 31: 312-313.

Igbal A., Khali, I.A., Ateeq N. and Khan M.S. (2006) Nutritional Qualities of Important Food Legumes. *Food Chemistry* 97(2): 331-335.

Isack, M.E., Lyimo, M. (2013) Post-Harvest Handling Practices on Physico-Chemical Composition of Tomato. *International Journal of Vegetable* 22(54).

Islam M. M., (2010). In: *Jute* (In Bengali version), Pub. By Dynamic Publisher. Bangladesh.

Iwe, M.O. (2010) *Handbook of sensory methods and analysis*. Rejoint communication services Ltd, Uwani-Enugu Nigeria

Kasim MU, Kazim R (2015). Colour quality of fresh-cut fruits and vegetables. *Sixth International Scientific Agricultural Symposium*. Pp 1007-1014

- Kitson RE, Mellon MG (2004). Colorimetric determination of Phosphorous as Molybdivanadophosphoric Acid. *Industrial and Engineering Chemistry. Analytical Edition.* 16: 379-383.
- Kola A., (1999) Analysis of the Nutritive Element of Some Nigerian Fruit Vegetables. Proceedings of 3rd Annual Conference of Nigerian Institute of Food Science and Technology held in Abuja p. 158.
- Kolawole OM, Kayode RMO, Aina J, Bukola (2010) Effect of solar drying on the proximate and microbial composition of *Abelmoschus esculentus*. *Journal of Agricultural Science.* 2010; 2:214-224
- Kolawole, O.M., Ayiboye, A.E., Aturah, E.E. and Anibijuwon, I.I. (2011) Effect of Oven Drying on the Proximate and Microbial Composition of *Abelmoschus esculentus*. *Journal Biotechnology* 1: 71-81.
- Mongi BS, Arya AB (2004). Effect of different modes of drying on moisture content and drying time of the selected vegetables. *The Indian Journal of Nutrition and Dietetics.* 41:293
- National Research Council (2006) Okra: Lost crops of Africa: Volume II: vegetables. Lost crops of Africa Vol. 2. National Academies Press. ISBN 978-0-309-10333-6.
- Nwaogu LA, Ujowundu CO, Mgbemena AL, (2000) Studies on the Nutritional and Phytochemical Composition of *Amaranthus hybridus* Leaves. *J Bio-Res;* (4): 28-31.
- Oguche, H.E. (2011) Effect of Drying Methods on Chemical Composition of Spinach "Aleifo" (*Amaranthus acquatica*) and Pumpkin Leaf (*Telfairia occidentalis*) and their Soup Meals. *Pakistan Journal of Nutrition* 10 (11): 1061-1065.
- Okafor J.C., (1983) Edible Indigenous Woody Plants in the Rural Economy of the Nigerian Forest Zone. In: *The Nigerian Rainforest Ecosystem* (D.U.U Okali, Ed). Proceeding of M.A.B. Workshop on the Nigerian Rainforest Ecosystem University of Ibadan, Nigeria.
- Olsen N. (2019). Benefits and Uses of Okro. *Medical News Today.* Accessed on the 20th February 2022
- Owolarafe OK, Shotonde HO (2004) Some physical properties of fresh okra fruit. *J Food Engineering* 63: 299-302.
- Oyelade OJ, Ade-Omowaye BIO, Adeomi VF (2003) Influence of variety on protein, fat contents and some physical characteristics of okra seeds. *J Food Engineering* 57: 111-114.
- Perera S, (2005) A study on some physiochemical properties of turkey okra (*Hibiscus esculenta*) seeds. (*Journal of Food Engineering*) 68: 73-78
- Robert C. (2010). *Vegan body building and fitness.* Healthy living publications. ISBN: 978-0-9843916-0-8.
- Satwase G. R., Pandhre P.G., Sirsat and YR., Wade, (2013) Studies on Drying Characteristic and Nutritional Composition of Drumstick Leaves by Using Sun, Shadow, Cabinet and Oven Drying Methods, *Open Access Scientific Reports, 2(1), 1-4.*
- Shivharea US, Gupta A, Bawa AS, Gupta P (2010) Drying characteristics and product quality of Okra. *Drying Technology* 18 (1-2); 409-419.
- Udofia US and Obizoba IC. (2005) Effect of Traditional Processing Techniques on Leafy Vegetables and Starchy Staple and their Uses in Traditional Soups and Dishes as Consumed in Akwa Ibom State. *J Biochem Investment.* (32): 1-11.
- Ukegbu, P.O. and Okereke, C.J. (2013) Effect of Solar and Sun drying Methods of the Nutrient Composition and Microbial Load in Selected Vegetables, African Spinach (*Amaranthus hybridus*), Fluted Pumpkin (*Telera accidentalis*), Okra (*Hibiscus esculentus*), Jute Leaves (*Chorchorus olitorius*), *Sky Journal of Food Science* Vol. 2 (5):35-40.
- United State Department of Agriculture (2014). National Nutrient Database for Standard Reference Release 28. Nutrient Data Laboratory. <http://www.ars.usda.gov/ba/bhnrc/ndi>. Accessed 14th February 2014
- Wachap E. (2005) Effect of Sun and Shade on Nutrient Qualities of Six Seasonal Green Leafy Vegetables used in Soups and Dishes in Taraba State, Nigeria (*Thesis in Nutrition Presented to Department of Nutrition*), Nsuka: University of Nigeria. Washington D.C. PP: 223-225.
- White, P.J. and Broadley, M.R. (2005) Bio-fortifying Crops with Essential Mineral Elements, *Trends Plant Science* 10:586-593.
- Wikipedia (2019). Coultate, T.P (200) *Food: The Chemistry of its Components.* 5th Edition, Royal Society of Chemistry. Pp 99



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