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EFFECT OF PROCESSING METHODS ON SELECTED PHYSICO CHEMICAL PROPERTIES OF OKRA (*Abelmoschus esculentus*)

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Abstract

Some physico chemical properties of okra under two different processing methods (boiled and dried okra) was carried out. The physicochemical properties considered in this study includes moisture content, specific heat, porosity, bulk density, viscosity, refractive index, carbohydrate, vitamin c, crude protein, crude fat, ash, fibre and colour. The methods used to determine the above named physicochemical properties respectively are as follows: oven dry method; method of mixture; toluene displacement method; measuring cylinder; viscometer; refracto-meter; soxhlet extraction method; macro kjeldahl method; macro kjedahl method; soxhlet extraction method; soxhlet extraction method; soxhlet extraction method; and sensory evaluation. Results obtained are as follows respectively; 42.75% for fresh okra, 82.61% for boiled okra and 10. 21% for dried okra sample; 16.15 J/kgK for fresh okra, 13.56 J/kgK for boiled okra and 8.59 J/kgK for dried okra; 32.7 % for fresh, 16.27 % for boiled and71.2 % for dried okra; 0.63 g/cm^3 for fresh, 1.24 g/cm^3 for boiled and 0.47 g/cm^3 dried okra; 348.33 N/m^2 for fresh, 458 N/m^2 for boiled and 298 N/m^2 dried okra; 1.47 for fresh, 2.63 for boiled and 0.93 dried okra; 22.29 % for fresh, 7.87% for boiled and 20.66 % for dried okra; 21.73 mg/100g for fresh, 6.17 mg/100g for boiled and 14.2 mg/100g dried okra; 10.24 % for fresh, 2.72 % for boiled and14.67 % for dried okra; 6.21 % for fresh, 0.11% for boiled and 9.68 % for dried okra; 9.16 % for fresh, 3.31% for boiled and 8.16 % for dried okra; 8.16 % for fresh, 3.44% for boiled and 36.62% dried okra; bright green for fresh okra, light green for both boiled and dried okra sample. ANOVA shows that processing methods has a significant effect ($p<0.05$) on all the physico chemical properties okra except colour. The study recommends that for nutritious value such as for protein, fat and fibre, the dried processing method is most beneficial since the value obtain for these nutrients using dried method are greater than boiled processing method. But for vitamin, ash and carbohydrate, it is advisable to maintain okra fresh.

Key Words: Processing methods, physico-chemical, okra

INTRODUCTION

Okra (*Abelmoschus esculentus*) is an annual crop belonging to the family Malvaceae. It is an important vegetable especially in West Africa, India, Brazil and the United State (Kembel *et al*, 2013). According to Burkil (1997), worldwide production of okra as fruit vegetable is estimated at six million tonnes per year. In West Africa, it is estimated at 500,000 to 600,000 tonnes per year. In Nigeria including Benue State, there are two distinct seasons for okra, the peak and the lean seasons. The physicochemical properties of Okra includes; refractive index, viscosity, colour, carbohydrate (sugar content), protein content, fat content, ash content, vitamin c, pH, bulk density, porosity and specific heat among others. According to Farinde, et al, (2006) okra is used largely as a vegetable in Africa and Nigeria in particular. Okra is valued for its edible green seed pods. Young fruit harvested before differentiation of fibres and full seed development, are consumed either alone or added as stews in the preparation of certain African sauces. Vegetables are rarely processed, presumably due to the general lack of basic preservation facilities for freezing, canning or dehydration.

In Nigeria, processing of okra is still traditional and under-utilized. In Benue State, particularly the Tiv people, Okra is processed by boiling in water to make draw soup. It is also sliced or dried whole to produce “Gyande” (sliced) or “Gbodi” (powdered). During the lean season, okra fruits are produced in low quantities, thus they are scarce and expensive. In the peak season, they are produced in large quantities much more than what the local populace can consume, thus leading to wastage. Proper processing and utilization of okra is necessary in order to harness both the economic, nutritional and health benefits of the commodity (*Bamire and Oke,* 2003)

Ndangui (2010) reported on the Nutritive Composition and Physicochemical properties of gumbo (*Abelmoschus* *esculentus L.*) seed and Oil. The chemical properties evaluated were moisture, crude protein, crude oil, crude ash, crude fiber, and crude energy. The oil from *A.esculentus*seeds was extracted using two oils extraction methods with petroleum ether (Soxlhet) and extraction with a mixture of chloroform: methanol (1:1) (Blye and Dyer).The oil concentration ranged from 24.90% (Soxlhet) to 21.98% (Blye & Dyer). They also work on minerals, viscosity, acidity, saponification value, iodine value, fatty acid methyl esters, unsaponifiable matter content, peroxide value, activation energy and differential scanning calorimetry were determined. Gumbo (*Abelmoschus esculentus* L.) is widely consumed as a fresh vegetable in both temperate and tropical countries. Although the seed pods are most often used, the mature seed is known to have superior nutritional quality.

Nwanekezi and Okorie, 2005 worked on sliced okra pieces prints that were processed by sulphiting and blanching. Treated and untreated (control) samples were stored under refrigeration (4–60C), frozen (-40C) and ambient temperatures (30 ± 20C). The ascorbic acid content, pH, titratable acidity, microbial load, viscosity and sensory properties of the samples were monitored every three weeks for 15 weeks. Within the total storage period, frozen blanched and sulphited okra lost 38% of its ascorbic acid, while the frozen untreated sample lost 66%. Both treated and untreated samples stored at refrigeration temperature lost 79% and 83% ascorbic acid respectively. The losses in ascorbic acid in treated and untreated solar dried samples were almost same, 68% and 66%. Frozen samples retained their viscosity better than refrigerated and solar dried ones. The pH of frozen and solar dried samples decreased with storage time while titratable acidity increased. The reverse was the case for refrigerated samples. Overall acceptability of blanched, sulphited and frozen okra was comparable to those of the fresh samples. Processing treatments of blanching and sulphiting in combination with frozen storage led to better retention of ascorbic acid content.

The economic important of Okra cannot be overemphasized. Okra contains carbohydrate, protein and vitamin C in Large quantities (*Adeboye and Oputa,* 1996). The essential and nonessential amino acids that okra contains are comparable to that of soybean. Hence it plays a vital role in human diet. Okra has several health benefits, as it is rich in vitamin A, thiamin, vitamin B_6, vitamin C, folic acid, riboflavin, calcium, zinc and dietary fiber. It also enriched with amino acids, with the like of tryptophan, cysteine and other sulfur amino acids (*Aminigo and Akingbala,* 2004). The mucilage and fiber found in okra helps adjust blood sugar by regulating its absorption in the small intestine. Okra is an excellent laxative treats irritable bowels, heals ulcers and sooths the gastrointestinal track. Protein and oil contained in the seeds of okra serve as the source of first-rate vegetable protein. It is enriched with amino acids of the likes of tryptophan, cysteine and other sulfur amino acids.

MATERIALS AND METHODS

Sample Preparation

Fresh okra pods were purchased from North Bank market Makurdi, Nigeria. The fresh okra pods were destalked and then washed with tap water then the water was drained using a basket (Fresh Sample (control)). The okra pods were boiled whole in boiling water for six (6) minutes to prepare the boiled sample. The pods were removed from the boiler and the water drained through a basket (Boiled Sample (process method 1)). The fresh Okra pods were sliced and sparely spread on racks and sundried at an average temperature of 36^0c until the slices became brittle. The pods were brought indoor at nights as the temperature during night falls. Sudden temperature change could put moisture back into the samples and lengthen the drying time. It took the pods two days to dry in the sun (Dried Sample (process method 2)). Both the boiled and dried okra pods were pounded using a mortar and pestle to obtain okra paste and coarse flour respectively (fig.1), from where the samples were collected for analysis.

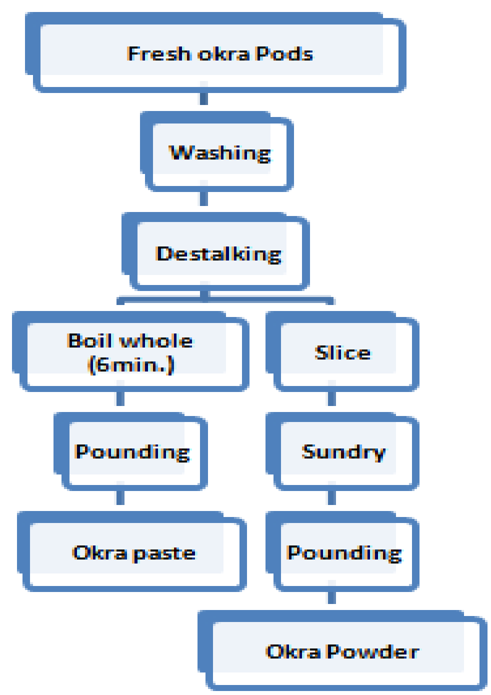

Figure 1: Flow chart for the preparation of boiled and sun dried okra samples

Moisture content

The method of AOAC (2005) was followed in determining the moisture content of all the three samples.

Crude Protein

The macro Kjeldahl method as described by AOAC (2005) was used, to determine the protein content.

Crude Fat

The soxhlet extraction method outlined in AOAC (2005) was used in determining the fat content of the samples.

$$pecentage\ fat = \frac{Weight\ of\ fat}{weight\ of\ samples}\ x\ 100$$

Crude fibre

The procedure outlined in AOAC (2005) was used to determine the crude fibre content of the samples.

$$pecentage\ crude\ fibre = \frac{Weight\ loss}{Weight\ of\ sample}\ x\ 100$$

Ash (Mineral)

The procedure outlined in AOAC (2005) was used in determining ash content of the samples.

$$Pecentage\ Ash\ content = \frac{Weight\ of\ Ash}{Weight\ of\ sample}\ x100$$

Carbohydrate

The procedure described by AOAC (2005) was used in determining the carbohydrate content.

$$Carbonhydrate\ = 100 - (\%protein + \%moisture + \%fat + \%crude\ fibre + \%ash)$$

Vitamin C (Ascorbic acid)

The vitamin C content of test sample was determined using AOAC (2005) method.

$$\text{Vitamin C in}\frac{\text{mg}}{\text{100g}} = \frac{\text{Titrate value x 0.212 x 100}}{\text{Wt. of sample}}$$

Specific heat

The specific heat of okra was determined using a calibrated copper calorimeter placed inside a flask, using the method of mixture as described by Aviara et al., 2011. The calorimeter was calibrated following the procedure described by Aviara and Haque (2001).

$$C_s = \frac{(M_c C_c + M_w C_w)\{T_w - (T_e - t'R')\}}{M_s\{(T_e + t'R') - T_s\}}$$

where, *Cc*= specific heat of calorimeter, J/kg K; *Cs*= specific heat of sample, J/kg K; *Cw*= specific heat of water, J/kg K; *mc*= mass of calorimeter, kg; *Ms*= mass of sample, kg; *Mw*= mass of water, kg; *Te*= equilibrium temperature of sample and water mixture, K; *Ts*=initial temperature of sample, K; *Tw*= initial temperature of water, K; *R*' =rate of temperature fall after equilibrium, K/s; *t*'= time taken for seed and water to come to equilibrium, s. The *t*'*R*' term accounted for the heat of hydration and heat exchange with the surrounding. The experiment was replicated thirty times at each moisture level and temperature range, and the average values of the specific heat were recorded and used in statistical analysis

Viscosity

Viscosity was determined using the method described by Onwuka (2005). Ten percent of the sample was suspended in distilled water and mechanically stirred for 1hours at room temperature using Oswald type viscometer and viscosity was measured.

Colour

Sensory evaluation of okra samples was on the basis of colour, acceptability using ten member untrained male and female adults that are familiar with the product in question. They were independently evaluated using the difference technique described by Larmond (1977). The nine-point hedonic scale was used to determine the preference of panelist. Ratings were from (1-9). One corresponds with extreme dislike and nine with extreme likeness.

Bulk and True Density

The bulk density was determined by the method described by Onwuka (2005). A 10ml graduated measuring cylinder was weighed and gently filled with the sample to the 10ml mark and then tapped on laboratory table several times until there was no further diminution of the sample and is was weighed.

$$Bulk\ Density = \frac{Weight\ of\ Sample}{Volume\ of\ sample}$$

The true density defined as the ratio of okra mass and true volume of okra was determined using toluene displacement method.

$$\rho_t = \frac{W_s}{V_s}$$

Porosity

The porosity was calculated from the average values of bulk density and true density using the relationship:

$$\Psi = \frac{\rho t' - \rho}{\rho t'}$$

Where

Ψ= porosity (%),

ρ= true density (g/cm^3), and

$\rho_{t'}$ = bulk density (g/cm^3).

Refractive Index

The refractive index was determined by the use of a refract-meter (IHP series Brownel London, Bellighan and Stanly Limited). Ten grams of the processed okra sample was mixed with 20g of water and strained directly through muslin. The refractive index of the drop of futrates at 30 was obtained by taking the corresponding reading on the refract meter. This procedure is described by AOAC (2005).

RESULTS AND DISCUSSION

The laboratory analysis results of the physico chemical properties of okra are presented in table 2. Table 1 presents the analysis of variance performed on the data to show the significant of processing method on some physico chemical properties of okra. While a figure 2 is the graphical presentations obtained for the physico chemical properties of fresh, boiled and dried okra.

Table 1: ANOVA on the effect of processing methods on some physiochemical properties of okra.

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Moisture	7890.83	2	3945.415	405350.88	4.054×10^{-16}*
Specific heat	88.63	2	44.315	1523.439	7.591×10^{-09}*
Viscosity	40160.222	2	20080.11	360.002	5.645×10^{-07}*
Refractive index	4.508	2	2.253	5664.578	1.483×10^{-10}*
Bulk density	0.981	2	0.491	2324.421	2.142×10^{-09}*
Porosity	4769.976	2	2384.988	235.026	2.002×10^{-06}*
Carbonhydrate	374.252	2	187.126	107269.63	2.187×10^{-14}*
Vitamin	363.45	2	181.725	1768.706	4.855×10^{-09}*
Protein	218.998	2	109.499	76991.633	5.915×10^{-14}*
Fat	140.853	2	70.427	14844.03	8.250×10^{-12}*
Ash	58.842	2	29.421	3465.829	6.469×10^{-10}*
Fibre	1884.214	2	942.107	346080.15	6.514×10^{-16}*

*significant (P<0.05)

Table 2: Effect of processing methods on some physiochemical properties of okra

Samples	Moisture Content %	Specific Heat J/Kg k	Viscosity N/m^2	Refractive Index	Bulk Density (g/cm^3)	Porosity %	Carbohydrate %	Vitamin 100g C(TU)	Colour	Crude Protein %	Crude Fat %	Ash %	Fibre %
Fresh okra	42.75^{b} (0.133)	16.15^{c} (0.079)	348.33^{b} (2.887)	1.470^{b} (0.008)	0.63^{b} (0.02)	32.7^{b} (0.3)	22.29^{c} (0.069)	21.73^{c} (0.551)	Bright green	10.24^{b} (0.017)	6.21^{b} (0.031)	9.16^{a} (0.114)	9.25^{b} (0.059)
Boiled okra	82.61^{c} (0.101)	13.56^{b} (0.1)	458^{c} (12.124)	2.63^{c} (0.032)	1.24^{c} (0.012)	16.27^{a} (0.208)	7.87^{a} (0.017)	6.17^{a} (0.07)	Light green	2.72^{a} (0.047)	0.11^{a} (0.0)	3.31^{a} (0.055)	3.38^{a} (0.067)
Dried okra	10.21^{a} (0.035)	8.59^{a} (0.266)	298^{a} (3.464)	0.93^{a} (0.01)	0.47^{a} (0.01)	71.2^{c} (5.505)	20.66^{b} (0.012)	14.2^{b} (0.0)	Light green	14.67^{c} (0.042)	9.68^{c} (0.115)	8.16^{b} (0.04)	36.62^{c} (0.17)

*Different letters within the same column indicate significant differences according to Duncan's New Multiple Range Test (*p*<0.05)

* Standard Deviations are shown in parenthesis

Moisture Content (%)

Table 1 shows that processing methods have a significant effect ($p<0.05$) on moisture content of okra after processing. The result in table 2 shows that the value of moisture content of fresh, boiled and dried okra that was measured ranges from 10.21 – 82.61 % and it was observed that fresh okra had the moisture content of 42.75%, boiled okra had the highest moisture content of 82.61% and dried okra had the least moisture content of 10.21%. Figure 2 shows the percentage representation of moisture content involved in the processing methods. It shows that moisture content of boiled process is twice that of the fresh okro and 10 times that of the dried process. The increased moisture of the boiled okra could be as a result of water absorption by the fibres and other natural chemical component during boiling.

Specific Heat (J/Kgk)

ANOVA (Table 1) shows that processing methods have a significant effect ($p<0.005$) on specific heat of processed okra. The result in table 2 show that the specific heat for fresh, boiled and dried okra that was measured ranged from 8.59 – 16.15 (J/Kgk) and it was observed that the specific heat of fresh okra had the highest value of 16.15 J/Kgk which could be because the fresh okra requires more heat to increase its temperature due to its internal molecular arrangement. Boiled okra had the value of 13.56 J/Kgk while that of dried okra was 8.59 J/Kgk which was the least value. This could be because the molecular structural arrangement of the Okra has been altered. Figure 2 shows that the specific heat value of dried and boiled okra is about half and one third the value of fresh okra respectively.

Porosity (%)

The porosity for fresh, boiled and dried okra ranges from 16.27 – 71.2 (%) (table 2) and it was observed that fresh okra has the value of 32.7 %; boiled okra has the least value of 16.27 % while dried okra had the highest value of 71.2 % which could be because the dried okra which is in powdered form can easily allow the penetration of fluid such as air or water through its surface. It was also observed that processing method has a significant effect ($p<0.05$) on porosity (table 1). Figure 2 shows that the porosity of dried processed okra was about twice that of fresh okra and four times that of boiled okra.boiled and dried okra ranges from 16.27 – 71.2 (%) (table 2) and it was observed that fresh okra has the value of 32.7 %; boiled okra has the least value of 16.27 % while dried okra had the highest value of 71.2 % which could be because the dried okra which is in powdered form can easily allow the penetration of fluid such as air or water through its surface. It was also observed that processing method has a significant effect ($p<0.05$) on porosity (table 1). Figure 2 shows that the porosity of dried processed okra was about twice that of fresh okra and four times that of boiled okra.

Bulk density (g/cm$^{3)}$

The result in table 2 show that the bulk density for fresh, boiled and dried okra ranges from 0.47 – 1.24 (g/cm^3) and it was observed that fresh okra has the value of 0.63 g/cm^3, boiled okra had the highest value of 1.24 g/cm^3 while dried okra had the least value of 0.47 g/cm^3. The processing methods was found to have a significant effect ($p<0.05$) on bulk density. The bulk density of boiled processed okra was found to be about twice that of both the fresh and dried okra (fig 2). This could be because of high present of moisture in the boiled okra.

Figure 2: Graphic display on the effect of processing methods on some physiochemical properties of Okra

Viscosity (N/m^2)

The result in table 2 show that the viscosity for fresh, boiled and dried okra value measured ranges from 298 – 458 (N/m^2) and it was observed that fresh okra had the value of 348.33 N/m^2; boiled okra had the highest value of 458 N/m^2 which could be because of the increase temperature of the boiled process which bind the water molecule with substance in the okra. While dried okra had the least value of 298 N/m^2. It was found that viscosity depend on the processing method (table 1). The viscosity value of dried and fresh okra is about half and two third the value of boiled okra respectively (fig 2).

Refractive index

The refractive index of fresh, boiled and dried okra value measured ranges from 0.93 – 1.47 and it was observed that the fresh okra had the value of 1.47; boiled okra had the highest value of 2.63(fig 2) which could be because of the constant absorption and remission of the particles of light, slowing down the speed at which light travels through it while that of dried okra was 0.93 which was the smallest value. It was confirmed that refractive index depend on the processing method (table 1) at 95%confident level. The refractive index of dried okra was found to be twice that of the fresh and three times that of the boiled processed okra.(fig. 2).

Carbohydrate (%)

The result shows that the carbohydrate for fresh, boiled and dried okra value measured ranges from 7.87 – 22.29 (%). It was observed that fresh okra has the highest value of 22.29 %; boiled okra had the least value of 7.87% while dried okra had value of 20.66 % (table 2) and this could be simply due to concentration of the nutrient as the moisture is highly reduced. Therefore carbohydrate is affected by method of processing (table 1). The study shows that the carbohydrate content of both the dried and fresh Okra was about twice that of the dried processed (fig 2).

Vitamin C (mg/100g)

Table 2 show that vitamin C for fresh, boiled and dried okra ranges from 6.17 – 21.73 (mg/100g) and it was observed that fresh okra had the value of 21.73 mg/100g which was the highest, boiled okra had 6.17 mg/100g which was the least while that of dried okra was 14.2 mg/100g. This could be because the heat used for the process could have destroyed some of the molecules of the vitamin C. the study shows that processing method has a significant effect on vitamin C (P<0,05). The vitamin C content of boiled okra was found to be about half that of the dried and one third that of the fresh okra.(fig. 2).

Crude Protein (%)

Crude protein for fresh, boiled and dried okra was measured ranges from 2.72 – 14.67 (%) and it was observed that fresh okra had the value of 10.24 %, boiled okra had 2.72 % which was the least while dried okra had the highest crude protein of 14.67 % (table 2). This result could be because the excessive heat involved in the boiled processed destroy the protein cells. While that of the dried processed okra could be because the heat involved could only remove the water content leaving the protein cells. I was noted that crude protein depends on the processing method (table 1) at 95% confident level. The percentage of crude protein of boiled okra was found to be about three times that of the fresh and five times that of the dried processed okra (fig. 2).

Crude Fat (%)

Crude fat for fresh, boiled and dried okra ranged from 0.11 – 9.68 (%) and it was observed that fresh okra had the value of 6.21 %, boiled okra had the least value of 0.11% while dried okra had the highest value of 9.68 % (table 2). The loss of fat during boiling could be due to oxidation reaction or leaching during cooking. It was also found that crude fat depend on the processing method at 95% confident level (table 1). The percentage of crude fat of boiled okra was found to be about forty times that of the fresh and sixty times that of the dried processed okra (fig. 2).

Ash (%)

Ash content for fresh, boiled and dried okra measured ranges from 3.31 – 9.16 (%) and it was observed that fresh okra had the highest value of 9.16 %; boiled okra had 3.31% value which was the least while dried okra had 8.16 % value (table). This is because the heat in involved in the boiled process destroys the ash contents of okra. It was also observed that processing method has a significant effect ($p<0.05$) on porosity (table 1). Figure 2 shows that the ask content of boiled processed okra was about twice that of fresh and dried processed okra.

Fibre (%)

The result in table 2 show that the fibre for fresh, boiled and dried okra measured ranged from 3.44 – 36.62 (%) and it was observed that fresh okra had the value of 9.25**%**; boiled okra had the least value of 3.44**%** while dried okra had the highest value of 36.62**%**. This is because the heat in involved in the boiled process destroys the fibre contents of okra. The result obtained shows that fibre depends on the processing method (table 1) at 95% confident level. The fibre content of the dried processed okra was found to be about four times that of the fresh okra and seven times that of the boiled processed (fig 2).

Colour

Table 2 shows bright green for fresh okra, light green for both boiled and dried okra sample.

Conclusion

From the results, the following conclusions can be made;

1. For the fresh okra, boiled and dried processed okra, the moisture content ranged from 10.21 – 82.61 %; specific heat from 8.59 – 16.15 (J/Kgk); porosity from 16.27 – 71.2 (%);bulk density from 0.47 – 1.24 (g/cm^3); viscosity from 298 – 458 (N/m^2); refractive index from 0.93 – 1.47; carbohydrate from 7.87 – 22.29 (%);vitamin C from 6.17 – 21.73 (mg/100g); crude protein from 2.72 – 14.67 (%);crude fat from 0.11 – 9.68 (%);ash content from 3.31 – 9.16 (%);fibre from 3.44 – 36.62 (%) and Colour was bright green for fresh okra, light green for both boiled and dried okra sample.

2. For all the parameters measured, it was found that the physico chemical properties of okra are significantly affected by processing methods (P<0.05).

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