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Research Article

Some Chemical Properties of Boiled and Fried Peppers (*Capsicum annum, Capsicum frutescens and Capsicum chinense*)

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Abstract

Pepper is a crop widely consumed for its nutritive value and taste. Boiling and frying are common methods used in pepper processing for palatability enhancement. This work was designed to investigate the effects of boiling and frying duration conditions on some chemical properties of pepper spp. Cleaned, destalked pepper *spp*. was cut into pieces (about 2 × 2 cm), 200 g of each were boiled in 1 litre of water for 5, 10, 15 and 20 minutes, while others stir-fried at 100 ± 10oC (fire temperature 210oC) in 1 litre of oil (refined soya oil) for same duration. Raw peppers were used as control. Samples were analysed for moisture, capsaicin, ash, protein, fibre, fat, carbohydrate, minerals, vitamin C and β-Carotene. Data were analysed using ANOVA at α0.05. Moisture and capsaicin contents were raw (85.7-88.2%; 170.0-194.0 mg/100g), boiled (89.9-93.6%; 63.7-132.7 mg/100g) and fried (1.4-72.7%; 61.7-120.0 mg/100g) peppers, respectively. Ash, protein, fibre, fat and carbohydrate contents of boiled peppers ranged from 0.1-0.71, 1.4-5.6, 2.4-4.1, 0.1-0.4 and 0.1-1.3%, while that of fried peppers varied from 1.0-4.4, 3.6-13.9, 2.2-30.4, 2.2-50.7 and 10.7-25.5%, respectively. Protein, sodium and flavonoid contents of the raw peppers differed significantly. Calcium, sodium, vitamin C, and β-Carotene of boiled peppers were 5.3-8.1 mg/g, 10.2-18.0 mg/g, 0.2-0.9 mg/g and 0.2-0.3 mg/g respectively. These significantly varied from that of fried peppers that ranged from 5.4-8.7, 8.6-21.7, 0.3-1.0 and 0.2-0.4 mg/g, respectively. It was concluded that boiling and frying of raw peppers altered their chemical properties.

Keywords: *Capsicum spp*; Frying; Boiling Pepper Duration; Chemical Properties

Introduction

Pepper (*Capsicum sp*) is an economically important crop belonging to the family *Solanaceae* which also includes other economically important crops such as tomato, potato and tobacco [1]. Peppers are considered the first spice to have been used by human beings and there is archaeological evidence of pepper and other fossil foods from as early as 6000 years ago [2]. This genus originated from Central and South America [3] and comprises about 30 species, of which five are domesticated that comprise *Capsicum annuum* L. (bell pepper), *Capsicum frutescens* L. (chilli pepper), *Capsicum chinense* Jacq (hebenero pepper), *Capsicum baccatum L.* and *Capsicum pubescens Ruiz and Pav*. The first three species are the most cultivated in both tropical and temperate zones. *Capsicum annuum* often forms a complex with *Capsicum frutescens and Capsicum chinense* [3].

Most vegetables are commonly cooked before being consumed in order to induce significant changes in chemical composition, influence the concentration and bioavailability of bioactive compounds in the vegetables [4]. However, both positive and negative effects have been reported depending upon differences in process conditions. Cooking processes, which are usually performed to increase the palatability and improve the edibility of food [5] can alter the physical characteristics and chemical compositions of the food. Although consumption of fresh unprocessed plant food is widely advocated, [6] observed a higher antioxidant capacity after all processing methods, except for vacuum boiling. Boiling and frying are generally regarded as destructive to food properties and this has fostered a belief among many consumers that raw vegetables are nutritionally superior to their frozen and/or cooked forms. Some studies have provided evidence that this may not always be the case [7]. Peppers (*Capsicum spp*.), which are grown worldwide, including Nigeria, are used extensively as spice and supplement for preparing soup, as natural food colorant and seasoning agent due to their attractive color, flavor and taste.

This research was structured to investigate effects of boiling and frying duration on some chemical properties of *Capsicum annum, Capsicum frutescens and Capsicum chinense.*

Materials and Methods

Sample preparation

The peppers [*Capsicum annum* (Bell), *Capsicum frutescens* (Chilli) *and Capsicum chinense* (Habanero)] were purchased from Mandate pepper market Ilorin, Kwara State of Nigeria (Figure a). The peppers were rinsed in water and dried on paper towels. The stem and seeds were removed, and edible parts were collected. These portions were cut in almost equally shaped small pieces (2 × 2 cm). Some portion of the sorted pepper was retained as raw and the remaining was heat treated (boiling and frying).

Figure a: 1a. *C. annum* (Bell), 1b. *C. chinense* (Habanero), 1c. *C. frutescens* (Chille)

Boiling

One litre of water was boiled in stainless steel pot of 3mm thickness. The pot was covered to prevent water loss. Two hundred grams of cut peppers was placed in the boiling water and cooked for 5, 10, 15 and 20 min. After boiling, the cooked peppers were drained for 1 min by using a wire mesh strainer and then analysed [8]. All heat treatments experiments were performed in triplicate, each using 200 g of pepper.

Frying

Refined bleached and deodorised vegetable oil (300 mL) was heated to 100 ± 5°C in a non-stick frying pan (20 cm diameter and 3mm thickness). Frying was done for four different times (5, 10, 15 and 20 min). Fried peppers were then placed in a clean dry towel allowing for the excess oil to drain. After each frying operation, the frying pan was thoroughly cleaned and the used oil was replaced with fresh one [9].

Proximate composition

The Standard methods of [10] were used for determining crude protein, fat, and ash contents. The crude fibre content of the sample was also determined using the method described in [10]. The carbohydrate content of sample was calculated by difference. The total of all the previously determined proximate parameters subtracted from 100 represent the carbohydrate content. As shown in equation 1

%Carbohydrate=100-%(Moisture+Ash+fibre+ protein+fat)--- (1)

Determination of crude protein

Principle: Protein in the sample was determined by Kjeldahl method. The samples were digested by heating with concentrated sulphuric acid (H_2SO_4) in the presence of digestion mixture. The mixture was then made alkaline. Ammonium sulphate thus formed, released ammonia which was collected in 2% boric acid solution and titrated against standard HCl. Total protein was calculated by multiplying the amount of nitrogen with appropriate factor (6.25) and the amount of protein was calculated. The Nitrogen content was calculated and multiplied with 6.25 to obtain the crude protein content. This is given in equation 2 as.

$$\%Nitrogen = \frac{(100xNx14xVF)T}{100xV_a} - - - (2)$$

where:

N= Normality of the titrate (0.1N), VF= Total volume of the digest= 100ml

T= Titre Value, V_a= Aliquot Volume distilled

Determination of crude fat

Crude fat was determined by ether extract method using Soxhlet apparatus. Approximately 1 g of moisture free sample was wrapped in filter paper, placed in fat free thimble and then introduced in the extraction tube. Weighed, cleaned and dried the receiving beaker was filled with petroleum ether and fitted into the apparatus. The water and heater were turned on to start extraction. After 4-6 siphoning allow ether to evaporate and disconnect beaker before last siphoning. The extract was transferred into clean glass dish with ether washing and evaporated ether on water bath. Then the was placed dish in an oven at 105 C for 2 hrs and cooled it in a desiccator. The percent crude fat was determined by using the following formula as shown in equation 3

$$\%Crudefat = \frac{Weightofetherextract}{Weightofsample} x \frac{100}{1} - - - -3)$$

Determination of ash

For the determination of ash, clean empty crucible was placed in a muffle furnace at 600 C for an hour, cooled in desiccator and then weight o of empty crucible was noted (W_1). One gram of each of 1 sample was taken in crucible (W_2). The sample was ignited over a burner with the help of blowpipe, until it is charred. Then the crucible was placed in muffle furnace at 550 C for 2-4 h. The appearances of gray white ash indicate complete oxidation of all organic

matter in the sample. After ashing furnace was switch off. The crucible was cooled and weighed (W_3). Percent ash was calculated by following formula:

$$\%Ash = \frac{Difference\ in\ weight\ of\ ash}{Weight\ of\ sample} x \frac{100}{1} - - - (4)$$

Determination of crude fiber content

A moisture free and ether extracted sample of crude fiber made of cellulose was first digested with dilute H_2SO_4 and then with dilute KOH solution. The undigested residue collected after digestion was ignited and loss in weight after ignition was registered as crude fiber. Calculations were done by using the formula as shown in equation 5

$$\%Crudefibre = \frac{W_1 - W_2}{W_0} x \frac{100}{1} - - - (5)$$

Mineral analyses

The method described by Association of Official Analytical Chemists [10] was used for mineral analysis (Potassium and Sodium). The samples were ashed at 550°C. The ash was boiled with 10 mL of 20% hydrochloric acid in a beaker and then filtered into a 100 mL standard flask. This was made up to the mark with deionised water. The minerals were determined from the resulting solution using Atomic Absorption Spectrophotometer (AAS Model Bulk Scientific Accuzy 211). All values were expressed in ppm (mg/100 g). Calcium was determined spectrophotometrically using UV/Visible Spectrophotometer model 752N.

Determination of capsaicin content of boiled and fried pepper

The capsaicin concentration of raw boiled and fried pepper samples was determined by spectrophotometric analysis of the blue colored component after reduction to lower acids of molybdenum from phosphomolybdic acid. With 10ml of dry acetone, one gram (lg) of each sample was extracted using a pestle and mortar. Samples were extracted by centrifugation at 10000 rpm for 10 minutes, and I ml of the supernatant was pipetted into a test tube and evaporated to dryness in a hot water bath (60°C). To dissolve the residue, 3 ml of 3 percent phosphomolybdic acid and 0.4 ml of NaOH solution were combined, agitated vigorously, and left to stand for 1 hour. At 650 nm, absorbance was evaluated for the clear blue solution, using reagent blank (5 ml of 0.4% NaOH+ 3ml of 3% phosphomolybdic acid). Standard curve was expressed as mg/100g on dry basic and was used to determine capsaicin content.

Estimation of vitamin C content

Ascorbic acid content was estimated by the method of [1]. A dye solution was prepared in which 42mg of sodium bicarbonate and 52mg of dichlorophenolindophenol were mixed in 200 mL of distilled water. In stock standard solution, 100 mg ascorbic acid was dissolved in 100 mL of 4% oxalic acid solution in a flask (1 mg/ml). For the preparation of working solution, 10 mL of the stock solution was diluted to 100 mL with 4% oxalic acid and the concentration of this working solution was taken 100 µg/ml. The ascorbic acid content was calculated by using the following equation 6.

Ascorbic acid (mg/100g)= 0.5 mg x V x 100 mL x 100---(6)

Where V (mL) is volume of dye used for the end point of sample

β-Carotene Estimation

Determination of beta-carotene content in pepper was done according to [12]. The content of beta-carotene in the pepper was quantified by spectrophotometry after extraction of the carotenoid from the pepper with chloroform. One milligram of the pepper was solubilised in 9 mL of chloroform, and the absorbance was read at 465 nm. The beta-carotene was quantified according to a calibration curve of pure beta-carotene in hexane.

Determination of total carotenoids content (TCC)

The total carotenoid analysis was performed according to the method of [13]. Consecutive extractions of carotenoids from 0.5 g samples were performed with acetone and petroleum ether (1:1, v/v) by using an Ultra Turrax homogenizer (T25, IKA Labor-technik Co., Staufen, Germany) until no more color was extracted. The upper phase was collected and combined with crude extracts after being washed several times with water. The extracts were made up to a known volume with petroleum ether. Total Carotenoids Content (TCC) was determined by recording the absorbance at 450 nm with a spectrophotometer (UV- 1650PC, Shimadzu, Kyoto, Japan). The Total Carotenoids Content **(**TCC) was expressed as milligrams of β-carotene equivalents per gramm fresh weight.

Statistical analysis

Statistical Analysis System (SAS) 9.1 software package was used for all statistical analyses. Analysis of variance (ANOVA) was performed and Duncan's multiple range tests was used to identify the significance among samples at $p < 0.05$. All results were expressed as means and standard deviation of three determinations.

Results and Discussion

Effect of heat treatment on the proximate composition of the pepper

The proximate compositions of raw and heat-treated peppers (*C. annum, C. chinense and C. frutescens*) were presented in tables 1, 2 and 3 respectively. The protein, fat, crude fiber and ash contents in raw *C. annum,* were 6.78, 0.07, 3.52 and 0.86%, respectively and in raw *C. chinense* were 3.44, 0.17, 3.97 and 0.45%, respectively, while in raw *C. frutescens* were 6.56, 0.14, 4.26 and 0.80%, respectively. The protein content of heat treated *C. annum* ranged from 2.7% in *C. annum* boiled for 15min *to* 8.5% for 5min fried *C. an-*

num respectively. The protein content of cooked *C. chinense* also ranged 1.43% for 5 min boiled and 5.45% for 15min fried *C. chinense* respectively. While protein in cooked *C. frutescens* pepper ranged from 4.02% for 20 min boiled and 13.89% for15 min fried *C. frutescens* respectively. The proximate composition of pepper was significantly ($p < 0.05$) affected by boiling and frying, though the effect varies with cultivar, type of heat treatment and duration of treatment. The proximate compositions of the raw peppers found in this study are similar to those shown in some previous research. The fat content and fiber are in line with the findings of [14] (0.30% fat, 2.73% fibre), while the mean protein content in this research is contrary to [14] but in the same trend with the findings of [15] that reported protein content of 4.1% in pepper. Generally, the heating process reduced the protein content though there some exception in the fried samples, the increase in the protein content of the fried pepper could be as a result of evaporation of water. In general pepper needs to be combined with other foods of high protein value in order to meet the protein requirements of individuals. This justifies the non-use of these pepper varieties as sole ingredients to provide the basic protein need, usually, crude protein in pepper needs supplementation with other protein condiments or animal proteins in meal.

The results show significant differences ($p < 0.05$) between moisture content of the raw pepper and that of the heat-treated samples. The fresh pepper (*C. annum*) has a moisture content of 87.56 ± 0.29% and the boiling process caused a significant ($p < 0.05$) increase with a percentage increase ranged from 4.2 to 6.9%, this is the same trend in the other *spp* (*C. chinense and C. frutescens*). The high levels of moisture in all the raw and boiled samples investigated suggests that the raw and boiled pepper cannot not be store for long under atmospheric condition without spoilage since high water activity could enhance microbial action bringing about food spoilage. Hence frying will make pepper stable against microbial activities.

Fat content of all the raw samples varied significantly ($p < 0.05$) from the heat treated samples and it is the same trend in all the three *spp*, though there were high fat content in the fried samples as a result of oil used in frying. The low values of fat in raw and boiled pepper varieties agree with the findings of many authors that pepper are poor sources of lipids [16].

Boiling significantly ($p < 0.05$) decreased crude fiber and ash contents, depending on the time of heat treatment; these decreases may be caused by diffusion of the contents into water and this affect distribution of the nutrients. The ash content is the total quantity of minerals present in the sample and the ash content in the raw pepper analysed in this research were 0.86 ± 0.002, 0.45 ± 0.04 and 0.80 ± 0.01% for *C. annum, C. chinense* and *C. frutescens* respectively. Mineral components show great changes during cooking operations, such as boiling, because of their solubility in water. Thus, frying had minimal effects on the nutrient composition of pepper while boiling significantly ($p < 0.05$) affect the distribution of the nutrients. The main change in the composition of pepper during frying is the loss of water due to the evaporation and absorption of the oil [17].

Sample	Moisture (%)	Ash (%)	Crude Fibre (%)	Crude Fat (%)	Crude protein (%)	CHO (%)
Raw	87.56 ± 0.29^{e}	0.86 ± 0.00^{e}	3.52 ± 0.26^{e}	0.07 ± 0.00^{e}	6.75 ± 0.04^{c}	1.25 ± 0.00^{e}
Boiled- 5min	91.20 ± 0.00^{d}	0.67 ± 0.00^{f}	3.02 ± 0.00^{f}	0.06 ± 0.00^{ef}	4.97 ± 0.02^{e}	0.11 ± 0.02^{h}
Boiled- 10min	92.40 ± 0.26^{b}	0.61 ± 0.00^{f}	3.50 ± 0.25^{e}	0.06 ± 0.00^{fg}	3.28 ± 0.02^{g}	0.16 ± 0.06^{g}
Boiled- 15min	93.60 ± 0.28^{a}	0.51 ± 0.00^{g}	3.01 ± 0.01^{f}	0.06 ± 0.00^{fg}	2.71 ± 0.29^{h}	0.16 ± 0.00^{g}
Boiled- 20min	92.00 ± 0.02^{c}	0.30 ± 0.00^{h}	2.40 ± 0.32^{g}	0.05 ± 0.00^{g}	4.39 ± 0.31^{f}	0.89 ± 0.00^{f}
Fried- 5min	72.3 ± 0.03^{f}	1.64 ± 0.01^{d}	4.70 ± 0.00^{d}	2.17 ± 0.00^{d}	8.51 ± 0.02^{a}	10.72 ± 0.01^{d}
Fried- 10min	45.40 ± 0.02^{g}	2.33 ± 0.00^{c}	9.03 ± 0.00^{c}	10.20 ± 0.00^{c}	7.58 ± 0.04^{b}	25.45 ± 0.02^{a}
Fried- 15min	5.52 ± 0.05^{h}	2.86 ± 0.17^{b}	14.87 ± 0.01^{b}	47.70 ± 0.01^{b}	5.92 ± 0.02^{d}	23.13 ± 0.03^{b}
Fried- 20min	2.47 ± 0.25^{i}	4.40 ± 0.13^{a}	23.21 ± 0.03^{a}	50.20 ± 0.01^{a}	4.80 ± 0.10^{e}	14.91 ± 0.01^{c}

Table 1: Proximate composition of raw and heat-treated *C. annum*.

Values are means of three independent experiments. Mean values having different superscripts within a column are significantly different ($p < 0.05$). CHO denotes carbohydrate content.

Effect of heat treatment and time on the mineral compositions

The quantity of calcium, potassium and sodium present in the raw and heat treated peppers were presented in tables 4, 5 and 6. The values for calcium for raw pepper ranged from 8.82, 8.49 and

Sample	Moisture (%)	Ash (%)	Crude fibre (%)	Crude fat (%)	Crude protein (%)	CHO (%)
Raw	88.24 ± 0.04^{c}	0.45 ± 0.04^{d}	3.97 ± 0.01^{d}	0.17 ± 0.02^{g}	3.44 ± 0.02^{f}	3.74 ± 0.04^{d}
Boiled- 5min	91.92 ± 0.01^{a}	0.36 ± 0.03^{e}	3.42 ± 0.00^{ef}	0.41 ± 0.02^{e}	1.43 ± 0.01^{i}	2.45 ± 0.05^{e}
Boiled- 10min	92.13 ± 0.02^{a}	0.26 ± 0.01^{f}	3.32 ± 0.01^{f}	0.23 ± 0.01^{f}	3.92 ± 0.01^{d}	0.15 ± 0.01^{f}
Boiled- 15min	92.08 ± 0.05^{a}	0.36 ± 0.04^{e}	3.84 ± 0.01^{de}	0.20 ± 0.01^{fg}	3.13 ± 0.02^{g}	0.38 ± 0.08^{f}
Boiled- 20min	91.06 ± 1.06^{b}	0.35 ± 0.04^{e}	2.69 ± 0.58^{g}	0.20 ± 0.01^{fg}	2.10 ± 0.01^{h}	3.60 ± 0.72^{d}
Fried- 5min	33.26 ± 0.03^{d}	2.61 ± 0.06^{b}	2.40 ± 0.06^{g}	31.34 ± 0.01^{d}	5.26 ± 0.04^{b}	25.13 ± 0.04^{a}
Fried- 10min	24.46 ± 0.02^{e}	3.09 ± 0.01^{b}	19.31 ± 0.01^{c}	32.61 ± 0.02^{c}	5.35 ± 0.01^{b}	15.18 ± 0.02^{b}
Fried- 15min	11.88 ± 0.02^{f}	3.44 ± 0.0^{a}	30.39 ± 0.52^{b}	35.62 ± 0.02^{b}	5.45 ± 0.04^{a}	13.22 ± 0.50^{b}
Fried- 20min	7.49 ± 0.09^{g}	2.17 ± 0.02^{c}	31.46 ± 0.02^{a}	45.46 ± 0.04^{a}	3.53 ± 0.04^{e}	9.89 ± 0.03^{c}

Table 2: Proximate composition of raw and heat treated *C. chinense.*

Values are means of three independent experiments. Mean values having different superscripts within a column are significantly different ($p < 0.05$). CHO denotes carbohydrate content.

Sample	Moisture (%)	Ash (%)	Crude fibre (%)	Crude fat (%)	Crude protein (%)	CHO (%)
Raw	85.66 ± 0.17^{d}	0.80 ± 0.01^{e}	4.26 ± 0.05^{e}	0.14 ± 0.00^{e}	6.56 ± 0.12^{d}	2.57 ± 0.00^{c}
Boiled- 5min	89.90 ± 0.01^{c}	0.45 ± 0.01^{g}	3.33 ± 0.03^{g}	0.14 ± 0.00^{e}	5.58 ± 0.03^{f}	0.60 ± 0.01^{g}
Boiled- 10min	90.03 ± 0.11^{c}	0.71 ± 0.00^{f}	4.14 ± 0.11^{f}	0.13 ± 0.00^{f}	4.82 ± 0.16^{g}	0.18 ± 0.05^{h}
Boiled- 15min	91.06 ± 0.01^{b}	0.44 ± 0.01^{g}	3.34 ± 0.01^{g}	0.12 ± 0.00^{g}	4.39 ± 0.02^{h}	0.65 ± 0.00^{f}
Boiled- 20min	92.63 ± 0.02^{a}	0.10 ± 0.01^{h}	3.01 ± 0.01^{h}	0.12 ± 0.00^{g}	4.02 ± 0.02^{i}	0.12 ± 0.00^{i}
Fried- 5min	67.22 ± 0.10^{e}	1.77 ± 0.03^{c}	7.11 ± 0.02^{d}	8.49 ± 0.01^{d}	5.94 ± 0.10^{e}	9.48 ± 0.00^{b}
Fried- 10min	20.05 ± 0.02^{f}	1.01 ± 0.00^{d}	19.90 ± 0.04^{c}	36.58 ± 0.00^{c}	10.20 ± 0.05^{c}	12.26 ± 0.00^{a}
Fried- 15min	1.365 ± 0.11^{g}	2.75 ± 0.01^{b}	30.01 ± 0.00^{b}	50.38 ± 0.00^{b}	13.89 ± 0.09^{a}	1.61 ± 0.01^{d}
Fried- 20min	1.37 ± 0.01^{g}	3.01 ± 0.00^{a}	30.11 ± 0.00^{a}	50.74 ± 0.01^{a}	13.21 ± 0.01^{b}	1.55 ± 0.00^{e}

Table 3: Proximate composition of raw and heat treated *C. frutescens.*

Values are means of three independent experiments. Mean values having different superscripts within a column are significantly different ($p < 0.05$). CHO denotes carbohydrate content.

5.90 mg/g, pottasium ranged between 4.73, 4.63 and 4.52 mg/g while sodium was 12.15, 18.68 and 13.91 mg/g for *C. frutescens, C. annum and C. chinense,* respectively. The results showed that calcium and potassium in pepper were significantly reduced ($p < 0.05$) by heat treatment and the loss increases with increased in duration of heating as observed in *C. annum and C. frutescens*. While in *C. chinense* fluctuation was observed in the calcium content in both methods of heat treatments and also the potassium content was not significantly different ($p \geq 0.05$) in most duration of the heat treatment. This could be as a result of some inherent factors peculiar to *C. chinense* cultivars. Generally the loss is less in frying method when compared with the boiling method. This could be as a result of leaching of the minerals in boiling. Mineral components show great changes during cooking operations, such as boiling, because of their solubility in water. However, their losses are much lower during frying in oil, as they are soluble in oil only in small amounts. The availability of some important minerals, such as calcium, magnesium, phosphorus and especially iron, may decrease, partially because of their binding in insoluble compounds.

The quantity of calcium, sodium, and potassium content of *capsicum spp* for both raw and heat treated samples in this study could contribute significant amount of these micronutrients to the recommended daily allowance of Calcium 0.8-1.2g/day [18], Sodium 0.8-1g/day [19] and Potassium 7.8-11.0g/day [20]. Peppers are good sources of calcium, sodium and potassium and can make some contribution to these micronutrient intakes, though it is normally used in small quantities in cooking. Sodium is an electrolyte which functions in the control of fluid balance in the body, controls extracellular fluid, and is essential for osmosis. It is important in maintaining acid-base balance in the body and participates in the transmission of nerve impulses essential for normal function [21]. Calcium, in combination with phosphorus, is a component of bones and teeth to give strength and hardness. It isneeded for normal nerve and muscle action, blood clotting, heart function and cell metabolism, hence peppers have health promoting properties.

Sample	Ca mg/g	K mg/g	Na mg/g
Raw	8.49 ± 0.07[a]	4.63 ± 0.00[a]	18.84 ± 0.01[d]
Boiled- 5min	5.63 ± 0.07[b]	4.30 ± 0.00[b]	18.04 ± 0.00[e]
Boiled- 10min	5.54 ± 0.00[c]	4.18 ± 0.01[c]	17.45 ± 0.14[f]
Boiled- 15min	5.43 ± 0.00[d]	4.13 ± 0.00[bcd]	16.05 ± 0.00[g]
Boiled- 20min	5.29 ± 0.08[f]	4.13 ± 0.01[bcd]	14.03 ± 0.03[h]
Fried- 5min	5.54 ± 0.00[c]	3.91 ± 0.13[d]	18.84 ± 0.08[d]
Fried- 10min	5.43 ± 0.01[d]	4.03 ± 0.09[cd]	20.40 ± 0.20[b]
Fried- 15min	5.43 ± 0.01[d]	4.03 ± 0.05[cd]	19.72 ± 0.09[c]
Fried- 20min	5.40 ± 0.00[e]	4.13 ± 0.10[bcd]	21.70 ± 0.07[a]

Table 4. Minerals content of raw and heat treated *C. annum*.

Values are means of three independent experiments. Mean values having different superscripts within a column are significantly different ($p < 0.05$).

Sample	Ca mg/g	K mg/g	Na mg/g
Raw	5.90 ± 0.07[e]	4.52 ± 0.09[a]	13.91 ± 0.06[e]
Boiled- 5min	6.38 ± 0.01[b]	4.43 ± 0.01[b]	17.30 ± 0.06[a]
Boiled- 10min	6.15 ± 0.01[c]	4.48 ± 0.01[ab]	16.80 ± 0.00[c]
Boiled- 15min	6.09 ± 0.01[cd]	4.48 ± 0.00[ab]	17.11 ± 0.01[b]
Boiled- 20min	5.91 ± 0.07[e]	4.55 ± 0.01[a]	16.70 ± 0.07[d]
Fried- 5min	5.97 ± 0.00[de]	4.47 ± 0.03[ab]	11.42 ± 0.02[h]
Fried- 10min	5.90 ± 0.00[e]	4.53 ± 0.03[a]	11.71 ± 0.01[g]
Fried- 15min	6.87 ± 0.13[a]	4.47 ± 0.01[ab]	8.56 ± 0.01[i]
Fried- 20min	5.92 ± 0.08[e]	4.52 ± 0.01[a]	13.82 ± 0.03[f]

Table 5: Minerals of raw and heat-treated *C. chinense.*

Values are means of three independent experiments. Mean values having different superscripts within a column are significantly different ($p < 0.05$).

Sample	Ca mg/g	K mg/g	Na mg/g
Raw	8.82 ± 0.08[a]	4.73 ± 0.04[a]	12.15 ± 0.00[d]
Boiled- 5min	8.06 ± 0.02[d]	3.95 ± 0.07[cd]	11.23 ± 0.00[e]
Boiled- 10min	7.70 ± 0.08[e]	3.89 ± 0.00[d]	11.00 ± 0.00[e]
Boiled- 15min	7.25 ± 0.03[f]	3.78 ± 0.02[e]	10.23 ± 0.00[f]
Boiled- 20min	6.89 ± 0.00[g]	3.60 ± 0.08[f]	10.23 ± 0.29[f]
Fried- 5min	8.67 ± 0.02[b]	4.08 ± 0.01[b]	12.06 ± 0.08[d]
Fried- 10min	8.63 ± 0.00[b]	4.03 ± 0.01[bc]	12.49 ± 0.24[c]
Fried- 15min	8.32 ± 0.01[c]	4.00 ± 0.00[bc]	12.89 ± 0.02[b]
Fried- 20min	8.01 ± 0.00[d]	3.89 ± 0.00[d]	13.96 ± 0.02[a]

Table 6: Minerals of raw and heat-treated *C. frutescens*.

Values are means of three independent experiments. Mean values having different superscripts within a column are significantly different ($p < 0.05$).

Effect of cooking methods and time on capsaicin content of pepper

The results of capsaicin content for raw, boiled and fired pepper are presented in figures 1 and 2, capsaicin content of the raw, boiled and fried pepper varied from 170.0 ± 0.6-194.0 ± 0.1 mg/100g, 63.7 ± 0.1-132.7 ± 0.6 mg/100g and 61.7 ± 0.2-120.0 ± 1.1mg/100g respectively. Capsaicin content of the raw pepper differed significantly from specie to specie. *Capsicum annum* (bell pepper) had the highest capsaicin content (194.00 mg/100g) while, *Capsicum chinense* (habanero) pepper had the lowest capsaicin content (166.7 ± 0.5 mg/100g). Frying decreases the capsacin content significantly compared to boiling method. The capsaicin content of the pepper decreased with increase in cooking time in both methods of cooking. The finding in this research was inline with result of [22]. and [15].

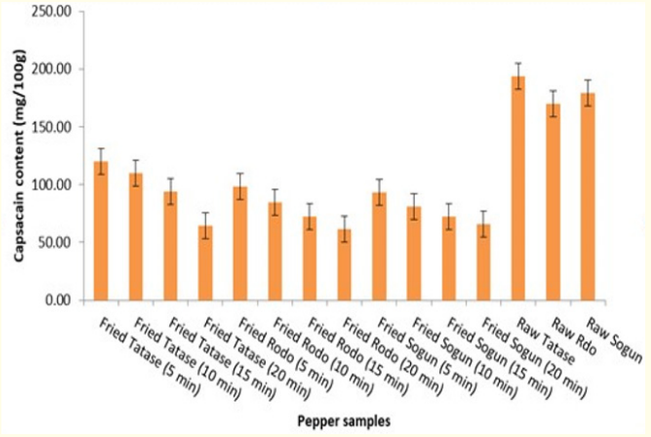

Figure 1: Capsaicin content of fried papper.

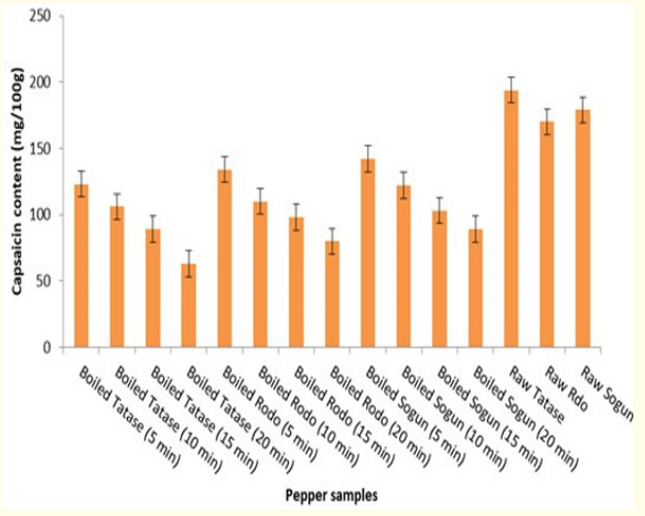

Figure 2: Capsaicin content of boiled pepper.

Effect of heat treatments and time on vitamin C Content

The effect of heat treatment and the duration on vitamin C content of the different *spp* of peppers and are shown in Table 7. The vitamin C content of raw pepper ranges from 0.79 mg/ g (*C. frutescens)*, 0.80mg/ g *(C. annum),* to 1.15 mg/g (*C. chinense).* While that of heat treated pepper ranged from 0.57mg /g (*C. annum* fried 5min) to 0.23mg/ g (*C. annum* boiled 20min), 1.09mg/ g (*C. chinense* fried 5min) to 0.71mg/g (*C. chinense* boiled 20min) and 0.74mg/g (C. frutescens fried 5min) to 0.28 mg/g (*C. frutescens* boiled 20min). In all the pepper samples analysed in this study *Capsicum chinense* had the highest vitamin C content, these results were similar to what [23] reported for polar extracts of some tropical vegetables. Ascorbic acid was significantly ($p < 0.05$) affected by boiling and frying, The highest level of decrease occurred in *C. annum* where boiling of 20min caused 71% loss in the vitamin C content, while *C. chinense* had the least loss (38.15%) in vitamin C content after boiling for 20min. The ascorbic acid concentration was less but significantly ($p \leq 0.05$) affected by frying with highest loss (69%) observed in 20min fried *C. annum.* This decrease in vitamin C content agrees with earlier findings of [23] on some tropical vegetables that reported 47.5 to 82.4% loss in vitamin C content during blanching of vegetables. It is well established that vitamin C content were destroyed during cooking due to the fact that they were not stable at high temperature [24].

It is well-known that heat induces a significant loss of ascorbic acid [25] but this loss was also found to be time-dependent in vegetables [26]. The result of the effect of two different heat treatments indicated that the highest reduction was noted in boiling than frying. The results showed that boiling resulted in high losses, while frying resulted in only small losses. Previous studies have shown that cooking reduces Vitamin C content in fruits and vegetables, including red pepper [13,27,28]. [27] reported that the Vitamin C levels in peppers decreased during cooking procedures such as boiling, microwave cooking, and stir- frying. Significant reductions were documented for boiling particularly due to the diffusion of Vitamin C into cooking water. [28] reported higher Vitamin C retention values in foods processed by stir-frying and microwave cooking than in those processed by boiling or blanching. Various studies report that cooking reduces Vitamin C content in food, including sweet chestnuts [29]. The amount of cooking-related loss of Vitamin C depends on several factors, including cooking method, heating temperature, cooking time, enzymatic oxidation during preparation, and surface area exposed to water and oxygen [27]. The reduction of the vitamin C content in cooked eggplant is the result of thermal treatment which is known to accelerate oxidation of ascorbic acid to dehydroascorbic acid, followed by the hydrolysis to 2, 3-diketogulonic acid and eventually polymerization to other nutritionally inactive components [27].

Sample	*C. annum*	*C. chinense*	*C. frutescense*
Raw	0.80 ± 0.45^{a}	1.14 ± 0.49^{a}	0.78 ± 1.12^{a}
Boiled- 5min	0.27 ± 0.08^{e}	0.87 ± 1.26^{f}	0.57 ± 1.12^{e}
Boiled- 10min	0.27 ± 0.23^{e}	0.78 ± 1.57^{g}	0.51 ± 0.02^{g}
Boiled- 15min	0.25 ± 0.04^{f}	0.75 ± 0.00^{h}	0.46 ± 0.30^{h}
Boiled- 20min	0.23 ± 0.05^{g}	0.71 ± 0.71^{i}	0.27 ± 0.07^{i}
Fried- 5min	0.57 ± 0.08^{b}	1.09 ± 0.38^{b}	0.73 ± 0.10^{b}
Fried- 10min	0.35 ± 0.24^{c}	1.02 ± 0.00^{c}	0.65 ± 0.48^{c}
Fried- 15min	0.33 ± 0.50^{d}	1.00 ± 0.29^{d}	0.60 ± 0.00^{d}
Fried- 20min	0.25 ± 0.00^{f}	0.96 ± 0.09^{e}	0.56 ± 0.02^{f}

Table 7: Vitamins of raw and heat treated peppers.

Values are means of three independent experiments. Mean values having different superscripts within a column are significantly different ($p < 0.05$).

Effect of Heat Treatment on Beta-Carotene

The effects of heat treatment on Beta-carotene in pepper are shown in Table 8. Beta-carotene of the raw peppers was 0.27 ± 0.00, 0.22 ± 0.02 and 0.27 ± 0.00mg/g in *C. annum, C. chinense and C. frutescens,* respectively. While for 20min boiled pepper were 0.21 ± 0.00, 0.16 ± 0.00 and 0.18 ± 0.00mg/g respectively. It was observed that Beta-carotene in pepper was significantly reduced ($p < 0.05$) by boiling in all the pepper but significantly increased ($p < 0.05$) by frying as compared to that in raw pepper. Boiling resulted to 22, 27 and 33% loss of Beta-carotenein C. annum, *C. chinense and C. frutescens* respectively. The results obtained from this research are in fair agreement to that of [30] that reported pronounced reduction in beta-carotene content of Lettuce, mint, green chilli, bringal, fresh been, bath sponge and bitter gourd as a result of boiling to be 47.6, 35, 55.3, 35.3, 24, 22 and19.3% respectively. About 62.7% and 14.9% of losses was also found in peas and capsicum respectively. [31] have also reported a reduction in β-carotene content in eggplant grilled for 4–5min using professional grilling apparatus. β-carotene is subjected to isomerization and oxidation, followed by cleavage because of its unsaturated structure, particularly under the influence of heat and light during processing or storage. The main degradation products identified are cis-isomers, mainly 13-cis- and 9-cis-b-carotene. It is hypothetically believed that boiling cause's rapid reduction in carotene content, many scientists also proved it by their research. The loss in β-carotene during processing is because transform change to cis form that are not biologically active.

Effect of Heat Treatments and Time on Total Carotenoid Content (TCC)

The effects of heat treatment on TCC in pepper are shown in Table 9. The TCC of the raw pepper were 0.62, 0.81 and 0.85mg/g in *C. annum, C. chinense and C. frutescens* respectively. The results

Sample	*C. annum*	*C. chinense*	*C. frutescense*
Raw	0.27 ± 0.00^{b}	0.22 ± 0.02^{b}	0.27 ± 0.00^{d}
Boiled- 5min	0.25 ± 0.01^{c}	0.22 ± 0.01^{b}	0.27 ± 0.00^{e}
Boiled- 10min	0.23 ± 0.00^{d}	0.21 ± 0.02^{bc}	0.22 ± 0.00^{f}
Boiled- 15min	0.21 ± 0.01^{e}	0.23 ± 0.02^{b}	0.21 ± 0.01^{g}
Boiled- 20min	0.21 ± 0.00^{e}	0.16 ± 0.00^{d}	0.18 ± 0.00^{h}
Fried- 5min	0.28 ± 0.00^{b}	0.21 ± 0.00^{bc}	0.34 ± 0.00^{a}
Fried- 10min	0.29 ± 0.01^{a}	0.19 ± 0.00^{c}	0.33 ± 0.00^{b}
Fried- 15min	0.30 ± 0.00^{a}	0.34 ± 0.01^{a}	0.30 ± 0.00^{c}
Fried- 20min	0.30 ± 0.00^{a}	0.36 ± 0.00^{a}	0.30 ± 0.00^{c}

Table 8: β-carotene of raw and heat treated peppers.

Values are means of three independent experiments. Mean values having different superscripts within a column are significantly different ($p < 0.05$).

Sample	*C. annum*	*C. chinense*	*C. frutescense*
Raw	0.62 ± 0.01^{e}	0.81 ± 0.00^{d}	0.85 ± 0.01^{b}
Boiled- 5min	0.56 ± 0.01^{f}	0.52 ± 0.00^{h}	0.77 ± 0.00^{e}
Boiled- 10min	0.54 ± 0.01^{g}	0.70 ± 0.00^{f}	0.76 ± 0.01^{e}
Boiled- 15min	0.52 ± 0.00^{h}	0.74 ± 0.00^{e}	0.71 ± 0.00^{f}
Boiled- 20min	0.45 ± 0.01^{i}	0.65 ± 0.00^{g}	0.64 ± 0.00^{g}
Fried- 5min	0.76 ± 0.01^{d}	1.09 ± 0.00^{c}	0.87 ± 0.01^{a}
Fried- 10min	0.86 ± 0.01^{c}	0.75 ± 0.01^{e}	0.84 ± 0.01^{bc}
Fried- 15min	0.93 ± 0.00^{b}	1.10 ± 0.00^{b}	0.83 ± 0.01^{cd}
Fried- 20min	0.98 ± 0.01^{a}	1.43 ± 0.00^{a}	0.82 ± 0.01^{d}

Table 9: Total carotenoid content of raw and heat treated peppers.

Values are means of three independent experiments. Mean values having different superscripts within a column are significantly different ($p < 0.05$).

showed that the TCC in pepper was significantly reduced ($p < 0.05$) by boiling in all the pepper but significantly increased ($p < 0.05$) by frying as compared to that in raw pepper. At frying time of 20 mins the TCC in *C. chinense* and *C. annum* significantly increased ($p < 0.05$) to 1.43 and 0.98mg/g, respectively, however there were no significant differences between *C. frutescens* boiled for 5 and 10mins (0.77 and 0.76mg/g) and also *C. chinense* boiled for 15mins and *C. chinense* fried for 10mins (0.75 and 0.74mg/g) are not significantly different (($p > 0.05$). In this study, frying significantly increased ($p < 0.05$) TCC in pepper as compared to boiling. These results of boiled pepper were similar to those of [27], who reported that TCC in peppers was reduced by 3.2- 36.0% and 11.6-40.9% by microwave heating and boiling, respectively. In addition, [22] found a 3-53% and 2- 46% loss of TCC in pungent and non-pungent peppers during boiling and grilling, respectively. Similar observations were reported by [32]. The heat treatment causes cis/trans isomerization of carotenoids, altering their biological activities and discolors the food. The decreased in TCC during boiling could be as a result of leaching of carotenoids into the boiling water due to their instability at the high temperature. The increased in TCC observed in frying method in this research was contrary to [33] that reported a decrease in concentrations of carotenoids during frying process. However it is in agreement with findings of several other researchers that reported that cooking may increase TCC because of its better extractability from heat treatment or dehydration of the food matrix[33]. Thermallability of carotenoids may be influenced by cooking conditions, food type, and the nature of the food matrix.

Conclusion

The study revealed the influence of boiling and frying on some chemical properties of three *spp*. of peppers [*Capsicum annum* (Bell), *Capsicum frutescens* (Chilli) *and Capsicum chinense* (Habanero)]. It was concluded that boiling and frying had significant influence on proximate composition of the peppers. There were pronounced reduction in protein, ash and fibre contents of the processed pepper samples, this is an indication that care has to be taken while processing pepper so as to avoid loss of nutrients because pepper is used as spice in food to provide nutrient in our diet. There was significant loss of vitamin C during boiling and frying, affirming the heat labiality of vitamin C. It heat treatment of these peppers beyond 15 minutes should be discouraged.

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