INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN APPLIED SCIENCE (IJRIAS)
ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

Influence of Processing Variables on Phytochemical Content of Dried 'Nsukka' Yellow Pepper (*Capsicum Annum L*)

***Justina Obianuju Idoko[1] and John Ikechukwu Eze[2]**

[1]Food Science and Technology Department, Institute of Management and Technology (IMT) Enugu State Nigeria

[2]Food Science and Technology Department, University of Nigeria Nsukka, Enugu State Nigeria

***Corresponding Authors**

DOI: https://doi.org/10.51584/IJRIAS.2025.100700062

Received: 22 May 2025; Accepted: 09 July 2025; Published: 08 August 2025

ABSTRACT

A study to investigate the effect of drying process variables including added vegetable oil at five different concentrations (3 – 10% (x_1)), blanching at five different times (2 – 5 min (x_2)) and drying at five different temperatures (50 – 90 ^{0}C (x_3)) on the phytochemical content of 'Nsukka' yellow pepper (*Capsicum annum L*) was conducted. Dried samples along with the fresh sample were subjected to phytochemical analysis (screening and quantification) for tannin, hydrogen cyanide, flavonoid, phenol, polyphenol, capsaicin and saponin. The screening results showed that tannin, flavonoid and phenol were present at high level (++, +++) while saponin, hydrogen cyanide and polyphenol were slightly detected (+) in dried and fresh samples. For dried samples, results for quantification were as follows: tannin195.71 – 276092 mg/100g, hydrogen cyanide 0.63 – 1.41 µg/100g, flavonoid 409.88 -734.49 mg/100g, phenol 614.19 – 1572.47 mg/100g, polyphenol 85.50 – 119.70 mg/100g, capsaicin 22.46 -36.01 mg/100g and saponin 1.19 – 1.58 mg/100g. Fresh yellow pepper sample yielded 296.21, 1.52, 766.75, 1784.52, 130.65, 46.65 and 1.92 mg/100g for tannin, hydrogen cyanide, flavonoid, phenol, polyphenol, capsaicin and saponin respectively. ANOVA values for response quadratic models indicated significant P-values for tannin, flavonoid, phenol, polyphenol, capsaicin and saponin. Only hydrogen cyanide showed a not significant Lack of Fit among the phytochemicals using model adequacy of ($P<0.05$) and Lack of Fit ($P>0.05$). Results obtained from the study revealed processing variables had blunting effect on the phytochemicals under investigation.

Key words: phytochemicals, variables, blunting, yellow pepper, drying, blanching.

INTRODUCTION

In Eastern Nigeria, ''Nsukka' yellow' pepper, a variety of *Capsicum annum* is popular and is considered among the principal grown crops in the derived savannah agro-ecology for its fruits which are characterized by unique aroma and hotness due to the capsaicin content, nutritional value, adaptability to the existing cropping system and potential for wealth creation (Abu and Odo, 2017). ''Nsukka' yellow' pepper is not widely cultivated in most states in the country, this may be because of its tendency to lose its pungency, aroma and colour in other areas outside 'Nsukka' (Uguru, 1999). It is peculiar to 'Nsukka' hence it is called ''Nsukka' yellow pepper (ose Nsukka in igbo language). Pepper generally is used in medicine due to the antioxidant, antimicrobial, antipyretic, anti-allergenic and anti-carcinogenic activities of the phytochemicals in them. These constituents are chemical compounds formed during the plant normal metabolic processes often referred to as secondary metabolites of which are several classes including alkaloids, flavonoids or tannins (Lee *et al.,* 1995).

Fresh pepper has very high moisture content. United States dietary allowances nutrient database describes pepper as 94% water vegetable. Fresh peppers are therefore perishable in nature and deteriorate within a few days after harvest especially in rainy season and these losses are further enhanced due to storage problems, marketing and lack of appropriate processing technologies (Rakesh *et al.,* 2015; FAO, 2003). To minimize the losses and to

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

provide remunerative returns to the growers, processing and preservation are the only alternatives. The primary preservation method for fruit and vegetable is drying. The main objective for drying is the reduction of the moisture content to a level which allows safe storage over an extended period thus extending the shelf-life (Tunde-Akintunde *et al.,* 2011).

Drying of food usually results in loss of nutrients and other undesirable changes which include discolouration and browning. Knowledge of pre-treatment methods that can improve the quality of dried products and the drying rate of food material is necessary in order to optimize the drying process. Blanching is a special heat treatment to inactivate enzymes. Cano (1996) described blanching as a thermal process used in combination with other methods and carried out by treating the fruits and vegetables with steam or hot water for 1 – 10 min at 75 – 95 ^{0}C. vegetable oils play important roles in food preparation by enhancing the flavour of food, adding texture to the food, making baked products crispier and helping in conducting heat during cooking. The presence of natural antioxidants like vitamin E (tocopherol and tocotrienols) increases the oxidative stability of food containing them.

Oils maybe added during manufacturing or be inherent to the product Addition of oil to water used for blanching helps to replace the initial outer wax layer, which is beneficial because of the protection it offers the fruit or vegetable from environmental and external factors (Tunde-Akintunde *et al.,* 2011). Added vegetable oil surrounds and impregnates the pigmentation of pepper and prevents degradation and gives the product a glossy appearance (Inanc *et al.,* 2010).

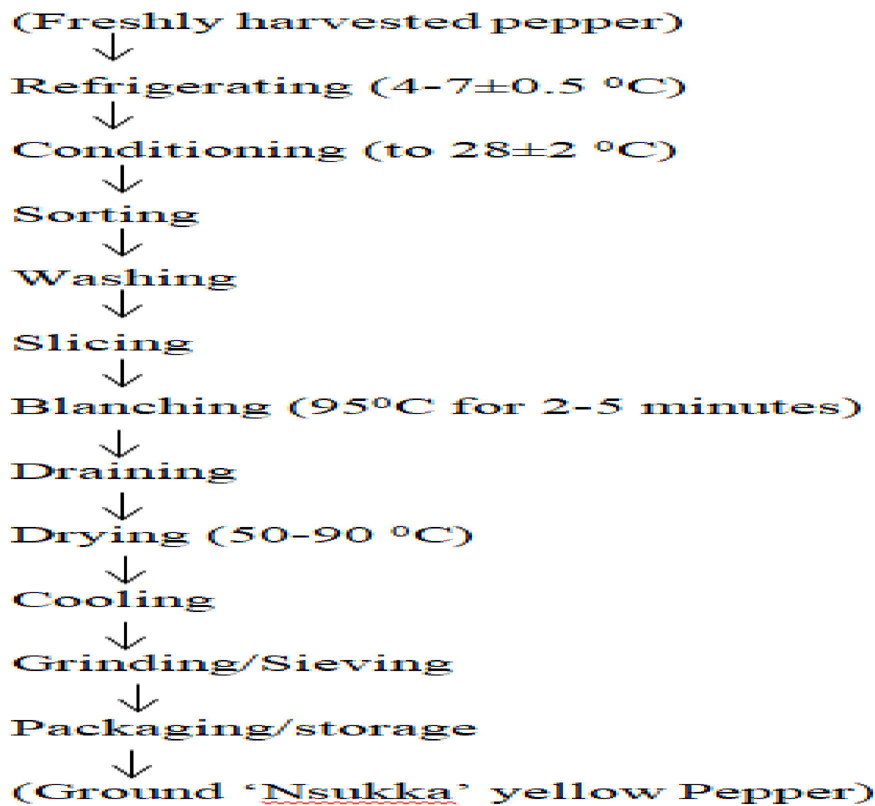
Most drying are done at air temperature between 50^{0}C – 80^{0}C (Wiriya *et al.,* 2009). For most fruits and vegetables, it is best to use drying temperatures of 50-55^{0}C (Wiriya *et al.,* 2009). For most fruits and vegetables, it is best to use drying temperatures of 50-55^{0}C because higher temperature can destroy nutrients and other components within (Mercer, 2012). Fresh 'Nsukka' yellow pepper is in category of product described as perishable, thus the current work tends to process it by drying using different blanching, oil addition and drying temperature variable and evaluate the effect on phytochemical constituent of the processed pepper.

MATERIALS AND METHODS

Materials

Fresh 'Nsukka' yellow pepper (*Capsicum annum L*) was harvested from a local farm in 'Nsukka' town, 'Nsukka' Local Government Area, Enugu State, Nigeria. The samples were stored in refrigerator at temperature of 4-7±0.5 ^{0}C before processing.

The modified method of Sachidananda *et al.* (2013); and Rakesh *et al.* (2015) was used. Before drying, the peppers were removed from refrigerator and allowed to acclimatize to room temperature (about 28±2 ^{0}C). The samples were sorted to remove the diseased, bruised and spotted ones, and also for colour, size, and any unwanted *Capsicum* species that may have been harvested along with the yellow pepper. The peppers were washed with potable water to remove dust and other extraneous materials from the surface of the fruits and to prevent incoming fruits from being contaminated, sliced using stainless steel knives to a slice thickness of 3 mm and slices were subjected to different pretreatments using blanching and oil before drying in hot air oven. The samples were cooled at 25^{0}C for 30 minutes, ground, sieved and packaged in high density polythene (HDPE) bags pending analysis. A flow chart that depicts the unit operations used in the sample preparation is presented in Fig. 1.



(Sachidananda *et al.,* 2013; Rakesh *et al.,* 2015)

Fig.1: Unit operations used in sample preparation

Experimental Design

A three factor central composite rotatable design (CCRD) was used to study the effect of oil concentration (X_1), blanching time (X_2) and drying temperature (X_3) on the phytochemical content of 'Nsukka' yellow pepper (*Capsicum annum L*). A total of twenty (20) runs were generated with fourteen experimental combinations and six replicates at the centre point. A total of five oil concentrations were used (0.61, 3.0, 6.5, 10.0 and 12.39%). Blanching times were varied at 0.98, 2.0, 3.5, 5.0 and 6.02 minutes. Also temperatures were varied at 36.36, 50, 70, 90 and 103.64^{0}C. The independent variables and their variation levels are shown in tables 1 and 2

Table 1: Independent variables and levels used for central composite rotatable design for 'Nsukka' yellow pepper (*Capsicum annum L*)

Parameters	Code	Coded variable level (X_i)				
Variable		-1.68	-1	0	+1	+1.68
Oil concentration (%)	X_1	3	4.42	6.5	8.58	10
Blanching time (mins)	X_2	2	2.61	3.5	4.39	5
Drying temperature (^{0}C)	X_3	50	58.11	70	81.89	90

Table 2: Experimental design for the experiment for 'Nsukka' yellow pepper in coded and actual values

Independent variable in coded form forms				Experimental variables in their actual values		
Design points	(X_1)	(X_2)	(X_3)	(X_1%)	(X_2 min)	(X_3 ^{0}C)

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

1	-1	-1	-1	4.42	2.61	58.11
2	+1	-1	-1	8.58	2.61	58.11
3	-1	+1	-1	4.42	4.39	58.11
4	+1	+1	-1	8.58	4.39	58.11
5	-1`	-1	+1	4.42	2.61	81.89
6	+1	-1	+1	8.58	2.61	81.89
7	-1	+1	+1	4.42	4.39	81.89
8	+1	+1	+1	8.58	4.39	81.89
9	-1.68	0	0	3	3.5	70
10	+1.68	0	0	10	3.5	70
11	0	-1.68	0	6.5	2	70
12	0	+1.68	0	6.5	5	70
13	0	0	-1.68	6.5	3.5	50
14	0	0	+1.68	6.5	3.5	90
15	0	0	0	6.5	3.5	70
16	0	0	0	6.5	3.5	70
17	0	0	0	6.5	3.5	70
18	0	0	0	6.5	3.3	70
19	0	0	0	6.5	3.5	70
20	0	0	0	6.5	3.5	70

Phytochemical Screening and Quantification

Phytochemical Screening

Screening was carried out as described by AOAC (2010). Qualitative analysis was carried out on the aqueous and ethanolic extracts of the 'Nsukka' yellow pepper samples to identify the constituents using Mayer's test for Alkaloids, Ferric chloride test for Tannins and Plenolics,, Alkaline reagent test for Flavonoids, Froth test for Saponins, Borntrager's test for Glycosides and Keeler-killani test for cardiac glycosides

Tannins

Tannin quantification was carried out using Folin's Dennis spectrophotometric method as in AOAC (2010). Five grams (5g) of the extract was dispersed in 50 mL of distilled water and shaken. The mixture was allowed to stand for 30 minutes at room temperature, and shaken every 10minutes. At the end of the 30 minutes, the mixture was filtered through What man filter paper and the filtrate was used for the experiment. Two milliliters (2 mL) of the extract was measured into a 50 mL volumetric flask. Similarly, 5 mL of standard tannic acid solution and

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

5 mL of distilled water were measured into separate flasks to serve as standard and blank respectively. They were further diluted with 35 mL distilled water separately and 1 mL of follin-Dennis reagent was added to each of the flasks, followed by 2.5 mL of saturated Sodium carbonate solution (Na_2CO_3). The content of each flask was then made up to 50 mL (with distilled water) and incubated for 90 minutes at room temperature. The absorbance of the developed colour was measured at 620nm wavelength in a spectrophotometer. Readings were taken with the reagent blank at zero. The tannin content was then calculated as follows

$$\text{Tannin (mg/100g)} = \frac{100}{1} \times \frac{A_u}{As} \times C \text{ x } \frac{V_f}{Va} \times Df$$

Where: V_a = weight of the sample

A_u = Absorbance of the test sample

A_s = Absorbance of the standard tannin solution

C = Concentration of standard mg/ mL

Vf = Volume of the extract analysed

Df = Dilution factor where applicable

Hydrogen Cyanide

The alkaline Picrate colourimetric method described by AOAC (2010) was used for quantification of hydrogen cyanide. Stripes of filter paper were cut from what man: No 1 filter paper. An alkaline picrate solution was prepared by dissolving 1g of picrate and 5g of Sodium carbonate in a small volume of minimally warm water and the volume was made up to 200 mL with distilled water. The picrate paper was prepared by dipping rectangular pieces of filter paper in picric acid solution and dried. One gram (1g) of each test sample was dispensed into 200 mL of distilled water in a 250 mL conical flask. An alkaline picrate paper was suspended in the flask and held in place with the stopper used to cork the flask. Care was taken to ensure that the picrate paper did not touch the surface of the flask. They were incubated at room temperature for 18 hours (overnight) and then each picrate paper was carefully removed and eluted in 60 mL distilled water. A standard cyanide solution was prepared (0.05m). The absorbance of the sample solution and standard was measured spectrophotometrically at 540nm using the reagent as blank to set the instrument at zero.

Amount of cyanide in 100g sample was computed using the formula

$$\text{HCN } \mu g/100g = \frac{100}{W} \times \frac{A_u}{A_s} \times C$$

Where: W = weight of sample

A_u = Absorbance of sample

A_s = Absorbance of standard solution

C = Concentration of standard

Flavonoid

Flavonoid content was determined gravimetrically using the method described by AOAC (2010). Five grams (5g) of the sample was boiled in 100 mL of 2M Hydrogen chloride solution for 30minutes. The boiled mixture was allowed to cool and then filtered through what man No: 42 filter paper. The filtrate was treated with Ethyl acetate starting with drop-wise addition until in excess. The precipitated flavonoid was recovered by filtration

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

using a weighed filter paper, and dried in an oven at $80^{O}C$, cooled in a desiccator and reweighed. The difference in weight gave the weight of flavonoid which was expressed as a percentage of the sample weight analyzed. The percentage flavonoid was calculated using the formula

$$\% \text{ flavonoid} = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

Where: W = weight of sample analyzed

W_1 = weight of the empty curable

W_2 = weight of the filter paper × flavonoid precipitate

Phenol

Total phenolic content of the 'Nsukka' yellow sample was estimated using Folin-Ciocalteau reagent by the method of AOAC (2010). Twenty micrograms (20 mg) of pepper sample was taken separately and made up to 1 mL with distilled water. Then 500 mL of diluted folin-ciocalteau reagent (1:1 ratio with water) and 2.5 mL of Sodium carbonate Na_2CO_3 (20%) were added. This mixture was shaken and incubated in dark condition for 40 minutes for the development of colour. After incubation the absorbance was measured at 725 nm. A calibration curve of gallic acid was constructed and linearity obtained in the range of 10-50 mg/ mL. Results were expressed as gallic acid equivalent per 100g of sample

Total Polyphenol

Total polyphenols was quantified by the Folin-Coicalteau method, according to AOAC (2010). The reaction mixture consisted of 500 mL sample in 4.5 mL water to which a solution of 200 mL Folin-Ciocalteau and 50 mL saturated Na_2CO_3 was added. After 1 hour, absorbance was read at 765 nm. Total pohyphenol content was calculated as Trolox equivalents. Trolox standard solutions were used for constructing the calibration curve. Total phenols content was expressed as mg Trolox equivalents per 100 g of sample.

Capsaicin Content.

Capsaicin content was determined from the samples following methods of proposed by AOAC 2010).

Extraction of capsaicin from fresh and dried samples

Ten grams of the ground sample was placed in a 250 mL flask with 100 mL of acetone. The sample was stirred for 1 hour at $25^{0}C$. It was filtered by vacuum and the volume of the supernatant was reduced to approximately 5 mL by removing acetone using gas nitrogen. The final solution was filtered through a 0.45 mm filter before injection to HPLC. Ten microlitres of extracted sample was injected for analysis by using HPLC equipped with a Luna C_{18} column (5μ, 250 x 4.6cm) and a UV detector at 284 nm. The mobile phase used a mixture of methanol and water (80:20 v/v) and a flow rate of 1.5mL/min. Capsaicin in each sample was identified and quantified by comparing it with capsaicin standard compounds ($\geq$95.0%, from capsicum species, sigma USA). Standard curves were prepared using serial dilutions of 0.1525, 0.3125, 0.625, 1.25, 2.5, 5, 10 and 20 mg/L capsaicin concentrations.

The capsaicin content in the sample extract was calculated using:

$$\text{Capsaicin content } (\%) = \frac{\text{Total SHU}}{16 \times 10{,}000}$$

Saponin Content

Saponin content of the samples was determined by the double solvent extracted gravimetric method as described by AOAC (2010). Five grams (5g) of the powdered sample was weighed and mixed with 50 mL of 20% aqueous

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

ethanol solution. The mixture was heated with periodic agitation on a water bath for 90 minutes at 55°C. It was filtered through Whatman No: 42 filter paper and the residue re-extracted with 50 mL of 20% ethanol, both extracts were combined together. The combined extracts were reduced to 40 mL over a water bath at 90°C. The concentrate was transferred into 250 mL separating funnel and 40 mL of diethyl ether was added and shaken vigorously. Separation was by partition during which the aqueous layer was recovered and the ether layer was discarded. Re-extraction by partition was done repeatedly until the aqueous layer became clear in colour. The saponins were extracted with 60 mL of normal butanol. The combined n-butanol extract were washed with 5% aqueous NaCl (Sodium chloride) solution and evaporated to dryness in a pre-weighed evaporating dish. It was further dried at 60°C in the oven and weighed. The saponin content was determined and expressed as percentage of the weight of analyzed sample using the formula:

$$\% \text{ Saponin} = \frac{W_2 - W_1}{W} \times 100$$

Where: W = weight of sample

W_1 = weight of empty evaporating dish

W_2 = weight of dish + saponin extract.

Data collected from the analysis were arranged as Central Composite Rotatable Design and analyzed statistically using Analysis of Variance (ANOVA) while the significant difference were separated via Duncan multiple range test using statistical package for social sciences version 8.0. The effect of oil concentration, blanching time and drying temperature on the phytochemicals was determined using Response Surface Methodology (Minitab version 16.1.1.0 2010) package. The independent and dependent variables were fitted to the second order model equation and examined for the goodness of Fit (Joglekar and May, 1987). The model fitting was carried out based on sequential P-value less than 0.05 ($P<0.05$), Lack of Fit greater than 0.05 ($P>0.05$) and the adjusted coefficient (R^2) value of 70%

RESULTS AND DISCUSSION

From the screening results (Table 3), tannin, flavonoids and phenol were present at high levels (++, +++) while saponin, hydrogen cyanide and polyphenol were slightly detected (+) in both dried and fresh samples. The different phytochemicals detected in the pepper samples was an indication of the rich potentials of ‘Nsukka’ yellow pepper for medicinal uses. For example, saponin protects against hypercholesterolemia and has anti-biotic properties (Harsha *et al.,* 2013). Tannins have been reported to have high medicinal value and also useful in textile industries as dyes and also as coagulants for clarification of beer in food industry (Nwalo *et al.,* 2017). Hydrogen cyanide is medicinally important due to its action on the heart (Emmanuel-Ikpeme *et al.,* 2014), helps in supporting its strength and rate of contraction when it is failing. At high concentration, it is a systemic poison due to its ability to inhibit cytochrome oxidase which prevents utilization of oxygen leading to central nervous system depression (EPA, 2010). Phenols show high level of antioxidant activity linked to the prevention of certain diseases in human body such as cancer (Olatunji and Afolayan, 2019). Flavonoid have been reported to be anticancer, anti-inflammatory and anti-microbial (Azeez *et al.,* 2012).

Polyphenols are a major determinant of the antioxidant capabilities of plants and are largely exploited groups of compound that have been utilized for chemotaxonomic classification of plants (Olatunji and Afolayan, 2019).

Table 3: Results of Qualitative analysis on phytochemical constituents of Dried ‘Nsukka’ Yellow Pepper

Expt. No.	Expt. Run	Oil concentration (%)	Blanching time (min)	Drying Temperature (^{0}C)	Saponin	Tannin	HCN	Flavonoid	Phenol	Polyphenol
1	11	3	2	50	+	++	+	++	++	+

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

2	9	10	2	50	+	++	+	++	++	+
3	2	3	5	50	+	++	+	+++	++	+
4	5	10	5	50	+	++	+	++	++	+
5	4	3	2	90	+	++	+	+++	++	+
6	15	10	2	90	+	++	+	++	++	+
7	1	3	5	90	+	++	+	++	++	+
8	13	10	5	90	+	++	+	+++	++	+
9	19	0.61	3.5	70	+	++	+	++	++	+
10	16	12.39	3.5	70	+	++	+	++	++	+
11	6	6.5	0.98	70	+	++	+	++	++	+
12	12	6.5	6.02	70	+	++	+	++	++	+
13	8	6.5	3.5	36.36	+	++	+	++	++	+
14	7	6.5	3.5	103.64	+	++	+	++	++	+
15	17	6.5	3.5	70	+	++	+	++	++	+
16	20	6.5	3.5	70	+	++	+	++	++	+
17	18	6.5	3.5	70	+	++	+	++	++	+
18	14	6.5	3.5	70	+	++	+	++	++	+
19	10	6.5	3.5	70	+	++	+	++	++	+
20	3	6.5	3.5	70	+	++	+	++	++	+
FNYP	-	-	-	-	+	++	+	+++	+++	+

(++, +++) = present at higher level

(+) = slightly detected

(FNYP) = Fresh 'Nsukka' yellow pepper

Results of the quantification of the phytochemical (Table 4) tannin values from the dried sample ranged from 195.71 – 276.92 mg/100g. Sample with oil concentration of 3%, blanching time of 2 min and drying temperature of 50^0C (experiment 1) had the highest value while sample with oil concentration of 6.5% blanching time of 3.5 min and drying temperature of 103.64 ^{0}C (experiment 14) had the least value. Significant differences ($p \leq 0.05$) existed among the samples. Values obtained from this study are higher than 1.44 mg/100g reported by Emmanuel-Ikpeme *et al.* (2014) from *Capsicum annum*, 0.142 – 0.164 mg/100g range values reported by Esayas *et al.* (2011) from *Capsicum annum* varieties grown in Ethiopia and 0.95 mg/100g obtained from dried 'Nsukka' yellow pepper by Aziagba *et al.* (2014). Values are however lower than 296.21 mg/100g obtained from Fresh 'Nsukka' yellow pepper (FNYP) samples, indicating that treatment lowered the tannin content of 'Nsukka' yellow pepper. Different blanching factors, such as time, temperature, material-to-water ratio, food matrix, cooking method/condition, and the chemical make-up of the phytochemical component (that leaches into blanching water and temperature), might all contribute to the inconsistent results (Asogwa *et al.,* 2021).

Hydrogen cyanide values from dried samples ranged from 0.63 to 1.41 µg/100g. Sample with oil concentration of 0.61%, blanching time of 3.5 min and drying temperature of 70^{0}C (experiment 9) had the highest value while samples with oil concentration of 6.5% blanching time of 3.5 min and drying temperature of 70 ^{0}C (experiments 15 - 20) had the least value. No significant differences (P≥0.05) existed among most of the samples. Values obtained from this study are higher than 0.55 mg/100g reported by Emmanuel-Ikpeme *et al.* (2014) from *Capsicum annum* and lower than 3.7 – 19.3 mg/100g reported by Nwalo *et al.* (2017) from medicinal plants. Range values obtained from dried samples are also lower than 1.52 µg/100g obtained from the fresh Nsukka' yellow pepper (FNYP), indicating treatment have daunting effect on the HCN of the samples analysed.

Flavonoid content of the dried samples ranged from 409.88 to 734.49 mg/100g. Sample with oil concentration of 6.5%, blanching time of 3.5 min and drying temperature of 36.36^{0}C (experiment 13) had the highest value while sample with oil concentration of 10% blanching time of 2 min and drying temperature of 50 ^{0}C (experiment 2) had the lowest value. No significant differences (P>0.05) existed among most of the samples. Values obtained from the dried samples are lower than 1223.71 – 1630.53mg/100g obtained from different *Capsicum* varieties by Olatunji and Afolayan (2019) but higher than 371.7 – 572.0 mg/100g obtained from dried *Capsicum* species by Shaima *et al.* (2016). Ranges of values are also lower than 766.75 mg/100g value obtained from fresh 'Nsukka' yellow pepper (FNYP). Variation in flavonoid values also indicate processing variables had influence on its content in 'Nsukka' yellow pepper. It has been reported the high temperature was used in heat treatment (boiling) degraded the flavonoid content (Alvarez-Parrilla *et al.,* 2011). The losses of flavonoid content during boiling was due to the flavonoid was leached into boiling water (Nurul and Norhayat, 2023).

Phenol values from dried samples ranged from 614.19 - 1572.47 mg/100g. Sample with oil concentration of 0.61%, blanching time of 3.5 min and drying temperature of 70^{0}C (experiment 9) had the highest value while samples with oil concentration of 6.5% blanching time of 3.5 min and drying temperature of 70 ^{0}C (experiments 15 - 20) had the least values. No significant differences (p≥0.05) existed among most of the samples. Ranges of values obtained are lower than 1784.52 mg/100g value obtained from fresh 'Nsukka' yellow pepper (FNYP). However, values are higher than 82.82 mg/100g obtained from dried red pepper by Ozgur *et al.* (2011) and 1480 mg/100g from dried minicomic yellow hot pepper by Cankaya *et al.* (2017). Blanching strongly affect the antioxidant activity of food which showed that thermal treatment affects the phytochemical constituents of pepper sample (Hwang *et al.,* 2012).

Polyphenol content of the dried 'Nsukka' yellow pepper samples ranged from 85.50 - 119.70 mg/100g. range values Are lower than 130.65 mg/100g obtained from fresh 'Nsukka' yellow pepper (FNYP). Dried sample with oil concentration of 3%, blanching time of 2 min and drying temperature of 50^{0}C (experiment 1) had the highest value of polyphenol while sample with oil concentration of 10% blanching time of 2 min and drying temperature of 50 ^{0}C (experiment 2) had the least values. There were no significant differences (p≥0.05) among most of the samples. Values obtained from dried sample are higher than 20.54 – 20.75 mg/100g reported by Campos *et al.* (2013) from Habanero pepper (*Capsicum chinense*). Boiling pepper can significantly impact its phytochemical composition, primarily reducing the levels of certain bioactive compounds. Specifically, boiling can also reduce the antioxidant compounds such as phenolics, and antioxidant activity, while also affecting capsaicinoids, the compounds that give peppers their pungency (Cankaya *et al.,* 2017).

The capsaicin content of the dried samples studied ranged from 22.46 - 36.01 mg/100g. Range values are lower than 46.65 mg/100g value obtained from fresh 'Nsukka' yellow pepper (FNYP). Sample with oil concentration of 0.61%, blanching time of 3.5 min and drying temperature of 70^{0}C (experiment 9) had the highest value while sample with oil concentration of 10%, blanching time of 2 min and drying temperature of 90 ^{0}C (experiment 6) had the lowest values. No significant differences (p≥0.05) existed among most of the samples. Values obtained from this study are higher than 2.26 – 2.42 mg/100g from chilli pepper dried at 45, 55 and 65 ^{0}C by Reis *et al.* (2013). Values are higher 6.31 mg/100g reported by Aziagba *et al.* (2014) for 'Nsukka' yellow pepper and 0.910.91 mg/100g from whole dried 'Nsukka' yellow pepper by Nwokem *et al.* (2010). Values are however lower than 160.7 – 170.80 mg/100g from dried red jalapeno spices by Enssaf and Mohsen (2016) and 62.84 mg/100g from yellow Habenero pepper by popelka *et al.* (2017). Variations may be attributed to differences in processing method.

Saponin content of the dried samples ranged 1.19 - 1.58 mg/100g. Values are lower than 192 mg/100g obtained from fresh 'Nsukka' yellow pepper samples. Sample with oil concentration of 3%, blanching time of 2 min and drying temperature of 50^{0}C (experiment 1) had the highest value while sample with oil concentration of 0.61% blanching time of 3.5 min and drying temperature of 70 ^{0}C (experiment 9) had the lowest values. Significant differences ($p \leq 0.05$) existed among ten of the samples studied while the other ten samples did not have any significant difference ($p \geq 0.05$). Values obtained from dried samples are lower than 3.76 mg/100g obtained from *Capsicum annum* by Emmanuel-Ikpeme *et al.* (2014) and 6.56 - 17.78 mg/100g range values from Nigerian long pepper (*Capsicum frutenscens*) by Bello *et al.* (2019). Higher values of capsaicin from the samples studied than most of the comparing values from the literature explains the high degree of pungency and hotness of ''Nsukka' yellow pepper. Lower value of saponin and hydrogen cyanide from the treated sample than FNYP indicate that vegetable oil has a blunting effect on them. Blanching in hot water decreases the antinutrients in plant products. This decrease during boiling may be caused by antinutrients leaking into the cooking water and being eliminated throughout the drying process (Tadewos *et al.,* 2023)

Table 4: Results of Phytochemical Contents of Dried 'Nsukka' Yellow Pepper samples

Expt. No.	Expt. Run	Oil concentration (%)	Blanching time (min)	Drying Temperature (^{0}C)	Tannin (mg/100g)	Hydrogen cyanide (µg/g)	Flavonoid (mg/100g)	Phenol (mg/100g)	polyphenol (mg /100g)	Capsaicin (mg/100g)	Saponin (mg/100g)
1	11	3	2	50	$276.92^{b}\pm3.691$	$1.11^{f}\pm0.006$	$467.16^{fg}\pm0.988$	$836.99^{h}\pm5.215$	$119.70^{b}\pm1.544$	$27.99^{e}\pm0.384$	$1.58^{b}\pm0.008$
2	9	10	2	50	$201.51^{h}\pm4.645$	$0.87^{l}\pm0.013$	$409.88^{l}\pm3.084$	$847.74^{g}\pm1.290$	$85.50^{k}\pm0.887$	$31.98^{c}\pm0.870$	$1.48^{c}\pm0.039$
3	2	3	5	50	$251.50^{c}\pm3.291$	$1.04^{h}\pm0.010$	$648.89^{e}\pm0.988$	$871.83^{f}\pm4.53$	$106.90^{de}\pm5.1.58$	$29.78^{d}\pm0.586$	$1.28^{g}\pm0.034$
4	5	10	5	50	$198.27^{h}\pm2.999$	$0.92^{j}\pm0.009$	$421.56^{ij}\pm2.534$	$918.28^{e}\pm5.818$	$102.43^{f}\pm1.68$	$26.58^{f}\pm0.528$	$1.46^{c}\pm0.047$
5	4	3	2	90	$240.07^{d}\pm2.346$	$1.36^{c}\pm0.011$	$698.27^{c}\pm1.307$	$850.32^{g}\pm8.461$	$107.99^{d}\pm1.523$	$31.39^{c}\pm0.762$	$1.39^{de}\pm0.017$
6	15	10	2	90	$221.98^{f}\pm1.564$	$1.13^{e}\pm0.005$	$469.79^{f}\pm2.720$	$801.72^{j}\pm6.098$	$111.95^{c}\pm1.011$	$22.46^{j}\pm0.202$	$1.20^{h}\pm0.025$
7	1	3	5	90	$247.41^{c}\pm2.576$	$0.89^{k}\pm0.007$	$436.05^{h}\pm4.305$	$818.06^{i}\pm3.871$	$113.97^{c}\pm0.758$	$24.22^{hi}\pm0.562$	$1.45^{cd}\pm0.017$
8	13	10	5	90	200.66 ± 3.583	$0.86^{l}\pm0.007$	$435.76^{h}\pm2.420$	$935.91^{d}\pm3.942$	$99.65^{g}\pm1.194$	$22.72^{j}\pm0.383$	$1.46^{cd}\pm0.022$
9	19	0.61	3.5	70	$232.05^{e}\pm2.819$	$1.41^{b}\pm0.006$	$660.58^{d}\pm4.588$	$1572.47^{b}\pm5.215$	$105.13^{e}\pm1.011$	$36.01^{b}\pm0.472$	$1.19^{h}\pm0.045$
10	16	12.39	3.5	70	$209.19^{g}\pm8.20$	$1.08^{g}\pm0.010$	$462.80^{g}\pm2.294$	$828.82^{h}\pm16.098$	$109.09^{d}\pm1.544$	$28.05^{e}\pm1.356$	$1.35^{ef}\pm0.017$
11	6	6.5	0.98	70	$225.91^{ef}\pm3.408$	$1.24^{d}\pm0.010$	$411.19^{l}\pm2.720$	$1001.72^{c}\pm3.247$	$112.45^{c}\pm0.758$	$25.14^{gh}\pm0.337$	$1.30^{fg}\pm0.014$
12	12	6.5	6.02	70	$231.54^{e}\pm2.82$	$1.03^{h}\pm0.011$	$417.12^{jk}\pm1.243$	$917.85^{e}\pm7.777$	$96.79^{h}\pm1.264$	$22.72^{j}\pm0.346$	$1.47^{c}\pm0.006$

13	8	6.5	3.5	36.36	201.34^{h}±2.58	0.84^{m}±0.006	734.49^{b}±2.49	827.53^{h}±4.531	94.60^{hi}±0.526	23.52^{ij}±0.241	1.32^{fg}±0.014
14	7	6.5	3.5	103.64	195.71^{h}±1.56	0.98^{i}±0.004	414.32^{kl}±3.47	614.19^{l}±3.414	90.30^{j}±0.526	25.75^{fg}±1.069	1.52^{bc}±0.039
15	17	6.5	3.5	70	198.27^{h}±2.131	0.63^{n}±0.010	422.55^{i}±1.243	650.32^{k}±8.462	94.09^{i}±3.918	28.34^{e}±0.241	1.35^{ef}±0.019
16	20	6.5	3.5	70	198.27^{h}±2.131	0.63^{n}±0.010	422.55^{i}±1.243	650.32^{k}±8.462	94.09^{i}±3.918	28.34^{e}±0.241	1.35^{ef}±0.019
17	18	6.5	3.5	70	198.27^{h}±2.131	0.63^{n}±0.010	422.55^{i}±1.243	650.32^{k}±8.462	94.09^{i}±3.918	28.34^{e}±0.241	1.35^{ef}±0.019
18	14	6.5	3.5	70	198.27^{h}±2.131	0.63^{n}±0.010	422.55^{i}±1.243	650.32^{k}±8.462	94.09^{i}±3.918	28.34^{e}±0.241	1.35^{ef}±0.019
19	10	6.5	3.5	70	198.27^{h}±2.131	0.63^{n}±0.010	422.55^{i}±1.243	650.32^{k}±8.462	94.09^{i}±3.918	28.34^{e}±0.241	1.35^{ef}±0.019
20	3	6.5	3.5	70	198.27^{h}±2.131	0.63^{n}±0.010	422.55^{i}±1.243	650.32^{k}±8.462	94.09^{i}±3.918	28.34^{e}±0.241	1.35^{ef}±0.019
FNYP	-	-	-	-	296.21^{a}±2.911	1.52^{a} ±0.013	766.75^{a}±3.213	1784.52^{a}±5.913	130.65^{a}±1.516	46.65^{a}±0.241	1.92^{a}±0.119

Data presented are mean and standard deviation values from triplicate samples. Means with the same superscript letters in the same column are not significantly different ($p \geq 0.05$) from each other

FNYP = Fresh ‘Nsukka’ Yellow Pepper

Model Fitting

Quadratic model fitting for the phytochemicals revealed tannin, flavonoid, phenol, polyphenol, saponin and capsaicin with significant Lack of Fit (Table 5) while hydrogen cyanide revealed a non-significant Lack of Fit (p=0.70), making the HCN fit into the model. A regression equation was thus obtained for prediction of HCN as follows:

$$HCN = 0.77 - 0.09x_1 - 0.08x_2 + 0.04x_3 + 0.04x_1x_2 + 0.11x_1x_3 - 0.09x_2x_3 + 0.15x_1^2 + 0.11x_2^2 + 0.03x_3^2 \text{---------Eqn 1}$$

Optimization procedure revealed that at a desirability function of 0.65, HCN value would be minimum (0.97 μg/100g) at 10% oil concentration, 5 minutes blanching time and 50^{0}C drying temperature.

Table 5: ANOVA Values for Response Quadratic models for Phytochemicals

Phytochemicals	Std. Dev.	Mean	C.V%	Press	R^2	Adj R^2	Pedic R^2	Adeq. Preci	P-value	P – lack of Fit	Significant Model
Tannin	14.62	216.38	6.76	15946.64	0.80	0.71	-.0.52	5.78	0.015822 significant	0.064201 not significant	Quadratic
HCN	0.10	0.97	9.86	0.34	0.89	0.79	0.60	9.16	0.000889 significant	0.703616 not significant	Quadratic
Flavonoid	77.68	481.27	16.14	488760.30	0.72	0.88	-1.23	5.4	0.055118 Significant	7.20x10^{-07} significant	-

Phenol	158.84	826.21	19.23	1916649	0.71	0.94	-1.23	5.97	0.0070942 significant	$7.20x10^{-08}$significant	-
Polyphenol	8.00	101.10	7.91	5243.63	0.61	0.76	-2.20	3.77	0.0202409 significant	0.000205 significant	-
Capsaicin	2.47	27.44	8.99	470.11	0.73	0.80	-1.04	7.73	0.046159 significant	0.082584 not significant	Quadratic
Saponin	0.10	1.37	6.96	0.43	0.45	0.75	-0.99	5.71	0.018102 significant	0.09875 not significant	-

Model is adequate when $p<0.05$, lack of fit ($p>0.05$), Adjusted R^2 ($\geq 70\%$)

CONCLUSION

A three factor central rotatable design (CCRD) was used to study the effect of oil concentration (x_1), blanching time (x_2), and drying temperature (x_3) on the phytochemical constituents of `Nsukka' yellow pepper (*Capsicum annum L*). Results indicated that the variables were significant on the predicted parameters responses. Variables predicted with model equations under the optimum processing condition were in general agreement with experimental data. All the phytochemicals constituents including tannin, hydrogen cyanide, flavonoid, phenol, polyphenol, capsaicin and saponin decreased in values indicating they are also not stable to processing conditions. Results obtained from the study revealed processing variables had blunting effect on the phytochemicals under investigation. However, the reductions in the value were gradual and within limits as to not negatively affect the samples.

REFERENCES

1. Abu, N. E. and Odo, C. V. (2017). The effect of plant density on growth and yield of Nsukka' Yellowaromatic pepper (Capsicum annum L). African Journal of Agricultural Research, **12**(15)1269-1277.
2. AOAC, (2010). Official methods of analysis 18th edition, Association of Official Analytical Chemists International Gaitherburg M.O
3. Asogwa, I. S., Ibrahim, A. N. and and Eze, J. C. (2021). The influence of cooking methods on the antioxidant. African Journal of Food, Agriculture, Nutrition and Development **21**(8): 18574–18592.
4. Azeez, L., Adeoye, M.D., Majolagbe, T.A., Lawal, A.T. and Badiru, R. (2012). Antioxidant activity and Phytochemical contents of some selected Nigerian Fruits and vegetables. American Journal of Chemistry **2**(4): 209-213
5. Aziagba, B. O., Okeke, C. U., Ufele, A. N., Ezeabara, C. A. and Muoka, R. O. (2014). Evaluation of three phytochemical constituents of seed extracts of three varieties of Capsicum annum in Awka, Anambra State, South Eastern Nigeria in relation to their medicinal value. International Journal of Agriculture and Bioscience **3** (2):82.84
6. Bello, J., Boboye, B. E. and Akinyosoye, F. A. (2019). Phytochemical screening and antibacterial properties of selected Nigerian long pepper (Capsicum frutescens) fruit. African Journal of Microbiology Research **9** (38): 2067 – 2078
7. Campos, M. R. S., Gomez, K. R., Ordonez, Y. M. and Ancona, D. B. (2013). Polyphenol, ascorbic acid, carotenoids content and antioxidant properties of habanero pepper (Capsicum chinense) fruit. Food and Nutrition Science **4**(1):47 – 54.
8. Cankaya, H., Hayoglu, I., and Turkoglu, H. (2017). A novel spice: pickled pepper powder and some quality Aspects. Polish Journal of foodand Nutrition Science **67**(1):19-24
9. Cano, M. P. (1996). Vegetable. In: freezing effect on food quality, Jeremiah, L. E. (Ed) Marcel Dekkar New York. P.520
10. Emmanuel-Ikpeme, C., Henry, P. and Okiri, A.O. (2014). Comparative evaluation of the nutritional, phytochemical and microbiological quality of three pepper varieties. Journal of Food and Nutrition Science **2**(3): 74 – 80

11. Enssaf, M. A. and Mohsen, M. S. (2016). Effect of different drying methods and storage on physico-chemical properties, capsaicinoid content and rehydration ability, colour parameters and bioactive compounds of dried red jalapeno pepper (Capsicum annum) slices. Middle East Journal of Applied Science **6**(4): 1012 – 1037.
12. EPA (2010). Toxicological review of Hydrogen cyanide and cyanide salts. www.epa.gov/iris .pg19downloaded22/04/2020
13. Esayas, K., Shimehs, A., Ashebir, F., Negussie, R., Tilahum, B. and Gulelat, D. (2011). Proximate composition, mineral content and anti-nutritional factors of some Capsicum (Capsicum annum) varieties grown in Ethiopia. Bull. Chem. Soc. Ethiopia 25(3): 451 – 454
14. FAO. (2003). Handling and preservation of fruits and vegetable by combined methods for Rural Areas (Barbosa-Canovas G. Ed). Bulletin 149. FAO Roma.
15. Harsha, N., Sridevi, V., Chandana-Lakshmi, M. V. V., Ravi, K. and Divyasatyavani, N. (2013). Phytochemical analysis of some selected spices. International Journal of Innovative Research in Science **2**(11): 6618 – 6621.
16. Inac, L. A., Demirli, M. and Alpaslan, M. (2010). Effect of vegetable cent on the quality parameters of red pepper during storing. Journal of Tekirdag Agricultural Faculty **7**(1):39-47
17. Joglekar, A.M. and May, A.T. (1987). Product excellence through design of experiment. Cereal Food World 32(1): 857-868
18. Lee, Y., Horward, L.R. and Villalon, B. (1995). Flavonoid and antioxidant activity of fresh pepper (Capsicum annum) cultivars. Journal of Food Science, 60 (3): 473-475
19. Mercer, D. G. (2012). A basic Guide to Drying Fruits and Vegetable Dept. of Food Science University of Guelph Ontarior Canada https://iuofst.org.21ufostftp.pdf.retrieved 04/07/21.
20. Nwalo, F. N., Echeta, J. O., Ude, G. D. and Itumo, M. O. (2017). Determination of phytochemical composition and antioxidant properties of selected medicinal plants in Ikwo, Ebonyi State, Nigeria. FUNAI Journal of Science and Technology **3**(2): 41 – 55
21. Nwokem, C. O., Agbaji, E. B., Kagbu, J. A. and Ekanem, E. J. (2010). Determination of Capsaicin content and pungency level of five different peppers grown in Nigeria. New York Science Journal **3**(9): 17 – 21
22. Olatunji, T. L. and Afolayan, A. J. (2019). Comparative quantitative study on phytochemical content and antioxidant activity of Capsicum annum L and Capsicum frutescens L). Hindawi , the Scientific World Journal. Volume 2019, Article ID 4705140 13 Pages, https://hdi.org/10.1155/2019/4705140
23. Ozgur, M., Ozcan, T., Akpinor-Bayizix, A. and Yilmaz-Ergan, L. (2011). Functional compounds and antioxidant properties of dried green and red peppers. African Journal of Agricultural Research **6** (25): 5638 – 5644
24. Popelka, P., Jevinva, P., Smejkal, K. and Roba, R. (2017). Determination of Capsaicin content and pungency levelof different fresh and dried chilli peppers. Folia Veterinaria **61** (2): 11-16
25. Rakesh, S., Joshi, V.K. and Kaushal, M. (2015). Effect of pretreatment and drying methods on quality attributes of sweet bell pepper (Capsicum annum L) powder. Journal of Food Science and Technology, 52(6): 3433-3439
26. Reis, R. C., Castro, V. C., Devilla, I. A., Olivera, C. A., Barbosa, L. S. and Rodovalho, R. (2013). Effect of drying temperature on the nutritional and antioxidant qualities of cumari perppers from para (Capsicum chinense Jacqui). Brazillian Journal of Chemical Engineering **30**(2): 337 – 343
27. Sachidananda, S., Samuel, D. V. K. and Abhijit, K. (2013). Effect of packaging materials on quality characteristics of osmotically pretreated microwave assisted dried sweet pepper (Capsicum annum L) Journal of Food Process Technology **4**(9): 34-38
28. Shaima, G. A., Mahmoud, M. S., Mohammed, M. R. and Emam, A. A. (2016). Effect of heat treatment on phenolic and flavonoid compound and antioxidant activities of some Egyptian sweet and chilli peppers. Natural Product Chemistry Research **4**(3): 200 - 218
29. Tadewos, H. M., Kebede, A. A., Engeda, D. A. and Juan, I. M. (2023). Effects of spices mixture and cooking on phytochemical content in Ethiopian spicy hot red pepper products. Food Sci Nutr **12**(7):4594–4604.
30. Tunde-Akintunde, T. Y., Akintunde, B. O. and Fabeja, A. (2011). Effect of Blanching Methods on drying of Bell Pepper. African Journal of Food, Agriculture, Nutrition and Development 111(7): 5457-5474

31. Uguru, M.I. (1999). Location effects on the growth, yield and flavour Expression of 'Nsukka' aromatic yellow pepper. J. Application of Chemistry Agricultural Resources **6** (1):84-87.
32. Wiriya, P., Paiboon, T. and Somchart, S. (2009). Effect of drying air temperature and chemical pretreatment on quality of dried chili. International Food Research Journal **16** (1): 441- 454.
33. Alvarez-Parrilla, E. R., Laura, A., Amarowicz, R. and Shahidi, F. (2011). Antioxidant activity of fresh and processed Jalapeño and Serrano peppers. Journal of Agricultural and Food Chemistry **59**(1): 163–173
34. Nurul, N. M. and Norhayat, M. (2023). Effect of heat treatment on phytochemical content and antioxidant activity of fresh and boiled capsicum annum variety Kulai. Enhanced Knowledge in Sciences and Technology 3 (1): 257-265
35. Hwang, I. G., Shin, Y. J., Seongeung, L., Junsoo, L. and Seon, M. Y. (2012). Effects of different cooking methods on the antioxidant properties of red pepper (Capsicum annuum L.). Prev Nutr Food Sci 17(1): 286～292