Effect of Drying Conditions on Nutrient Content of Dried 'Nsukka' Yellow Pepper (Capsicum Annuum L)

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ABSTRACT

The effect of drying conditions such as adding different concentration of oil (3-10% (X_1)), blanching for different times (2-5 min (X_2)) and drying oven temperature (50-90^{o}C (X_3) on the nutritional content of dried 'Nsukka' yellow pepper (Capsicum annuum L) were investigated. The nutrient evaluated were sodium, potassium, vitamin B_2, B_3, B_6 and vitamin C. Using the three factors Central Composite Design (CCRD), 20 experimental runs were generated with 14 experimental combinations and size replicates at the centre. Dried and fresh samples were subjected to chemical analysis for the nutrient studied. Models were developed and appropriate statistical analysis adopted to test the adequacy of the models. Response surface methodology was used as the optimization technique. Results showed sodium values ranging from 96.62 – 276.40 mg/100g, potassium 306.97 – 1153.23 mg/100g, vitamin B_2 0.19 – 6.19 mg/100g, vitamin B_3 0.90 – 8.26 mg/100g, vitamin B_6 0.09 – 1.94 mg/100g and vitamin C 1.40 – 4.14 mg/100g. Some of the experimental data were significantly difference ($P \leq 0.05$) while others did not show any significant difference ($P \geq 0.05$). The model Adj. R^2 were 0.19, 0.72, 0.90, 0.78, 0.83 and 0.70 for sodium, potassium, vitamin B_2, B_3, B_6 and vitamin C respectively, indicating that apart from sodium, models could be used to effect optimization process. Optimization suggested 10% oil concentration, 5 min blanching time and 50^{o}C drying temperature as the optimum drying conditions. This condition gave optimally dried 'Nsukka' yellow pepper with 918.28 mg/100g potassium, 2.87 mg/100g vitamin B_2, 7.68 mg/100g vitamin B_3, 1.24 mg/100g vitamin B_6 3.26 mg/100g vitamin C at desirability of 65%

Keywords: 'Nsukka' yellow pepper, optimization, drying condition, nutrient

INTRODUCTION

The 'Nsukka yellow' pepper, a variety of Capsicum annuum, is well-known and regarded as one of the main crops grown in the derived savannah agro-ecology. Its fruits are notable for their distinctive aroma and spiciness, which come from their capsaicin content, as well as their nutritional value, compatibility with existing farming systems, and potential for generating income (Abu and Odo, 2017). However, 'Nsukka yellow' pepper is not widely cultivated in many states across the country, possibly because it tends to lose its pungency, aroma, and color when grown outside the 'Nsukka' area (Uguru, 1999). It is unique to 'Nsukka', which is why it is named 'Nsukka yellow pepper' (ose Nsukka in the Igbo language).

Peppers are among the richest sources of vitamin C (ascorbic acid). In fact, vitamin C was first isolated from peppers in 1928 by Hungarian biochemist Albert Szent-Györgyi, who later received the Nobel Prize in Physiology or Medicine for his research on the vitamin. Fresh peppers can contain up to 340 mg of vitamin C per 100 grams, but this content decreases by 30% after canning or cooking and becomes almost negligible after drying (Bosland and Votata, 2012). Capsicum is also a good source of B-complex vitamins such as niacin, pyridoxine (vitamin B_6), riboflavin, and thiamin (vitamin B_1). These vitamins are essential because the body cannot produce them and must o btain them from external sources. B-complex vitamins support cellular

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metabolism by facilitating various enzymatic functions.

Potassium is the most plentiful individual mineral found in fruits and vegetables, typically ranging from 60 to 600 mg per 100 grams of fresh tissue (Ariel et al., 2009). A diet high in potassium helps reduce blood pressure. Potassium also plays a key role in regulating heartbeats, aiding muscle contractions, transmitting nerve impulses, and releasing energy from fats, carbohydrates, and proteins. Sodium, a systemic ion, is crucial for maintaining electrolyte balance and regulating ATP in relation to potassium. The intake of sodium in human diets has increased due to higher consumption of processed vegetables. Generally, fruits contain low levels of sodium and are recommended for diets that require low sodium intake (Ariel et al., 2009).

Drying is one of the oldest methods for preserving food, which concentrates nutrient content without the need for additives. This process can change the original sensory properties of food, creating new products and enabling their use in various formulations, thereby enhancing the taste and quality of other foods (Reis et al., 2013). Drying is a complex procedure involving simultaneous and interconnected heat, mass, and momentum transfer. For most fruits and vegetables, drying at temperatures between 50 and 55°C is ideal, as higher temperatures can damage nutrients and other components (Mercer, 2012). Blanching is a specific heat treatment used to deactivate enzymes. According to Cano (1996), blanching is a thermal process combined with other methods, where fruits and vegetables are treated with steam or hot water for 1 to 10 minutes at temperatures between 75 and 95°C. Oil may be added during processing or naturally present in the food. Adding oil to the blanching water helps restore the outer wax layer, which protects the fruit or vegetable from environmental and external factors. The added vegetable oil coats and penetrates the pigments in peppers, preventing their degradation and giving the product a shiny appearance (Inac et al., 2010). The objectives of this work were to study the effect of oil addition, blanching and drying on sodium, potassium and water soluble vitamins (B_2, B_3, B_6 and vitamin C) using Response Surface Methodology.

Materials and Methods

Fresh 'Nsukka' yellow pepper (Capsicum annum L) was harvested from 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^{o}C before processing.

Modified method of Sachidananda et al. (2013) was used. Before drying, pepper was removed from refrigerator and allowed to acclimatize to room temperature (about 28±2^{o}C. samples were sorted to remove the diseased, bruised and spotted ones, also for colours, size and unwanted Capsicum species that may have been harvested along with the yellow pepper. 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 sickness of 3 mm and slices were subjected to different pretreatments using oil and blanching before drying in hot air oven. Samples were cooled at 25^{o}C for 30 minutes, ground, sieved and packaged in high density polyethylene (HDPE) bags pending analysis.

Experimental Design

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 nutrient composition of 'Nsukka' yellow pepper (Capsicum annum L). A total of twenty (20) runs were generated with fourteen (14) experimental combinations and size replicate at 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, temperature was varied at 36.36, 50, 70, 90 and 103.64^{o}C. the independent variables and their variations are shown in Table 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

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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)
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

Vitamin Content Determination

Vitamins under this study determined by Official Method of the Association of Official Analytical Chemist

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(AOAC, 2010)

Determination of Vitamin C (Ascorbic Acid)

About 2 g of the pepper sample was weighed and ground into a powder. About 100 mL of distilled water was added to the powder in a volumetric flask, and then filtered to get a clear solution. Exactly 10 mL of the filtrate was pipetted into small flasks in which 2.5 mL acetone was added. Titration was carried out with indophenol solution (2,6-dichlorophenol indophenol) to a faint pink colour which persisted for 15 secs. Vitamin C content was then calculated using the formula given as follows:

Vitamin C (Mg/100g) = 20(v) (c)

Where

V = mL indophenol solution in titration

C = mg vitamin c/ mL indophenol

The indophenol was standardized by pipetting 10 mL standard ascorbic acid solution into a small flask and titrated with indophenol solution until a faint pink colour persisted for 15secs. The concentration of ascorbic acid was expressed as mg ascorbic acid equivalent to 1 mL of the dye solution (i.e 10 mL ascorbic acid solution = 0.002g ascorbic acid).

If .002g ascorbic acid required V mL dye solution to neutralize it, then 1 mL dye solution

$$= \frac{0.002\text{g ascorbic acid}}{V}$$

Determination of Vitamin B_2 (Riboflavin)

Riboflavin content was quantified by the method of AOAC (2010). In a 100 mL beaker, exactly 10 g of the pepper sample was weighed. 10-20 mL sulphuric acid (0.1m) was added. The sample was agitated with a glass rod and more 0.1m sulphuric acid added to around 50 mL. Slurry was obtained, without any lumps. The beaker was covered with aluminum foil or a watch glass and sterilized in an autoclave for 15minutes at 121-123^{0}C. The hot solution was transferred to a 100 mL volumetric flask containing 8 mL of 2m-soduim acetate. The solution was cooled down and 5 m of 10% amylase suspension added and incubated at 40^{0}C for 20 minutes. The solution was cooled and made up to volume with distilled water. The solution was filtered through a glass funnel with filter paper Whatman No: 41 and the first 5-10 mL of the filtrates discarded. Exactly 4.0 mL of the filtrate obtained was pipetted into a centrifuge tube which contains 4.0 mL methanol and mixed. The centrifuge was used to separate the precipitate from the supernatant liquid. Exactly 4.0 mL of the clear supernatant was pipetted into a test tube, diluted with 20 mL water and mixed on a vertex mixer. This was the final extract of the sample for HPLC, and it was filtered through a 0.45 µm membrane and injected into the HPLC for elution. Using the standard curve height (y) vs concentration – mg/L (x) for the standard concentration to generate the equation

Y = 1E08x -144138 with correlation coefficient (0.999) the concentration of riboflavin was calculated thus:

$$\text{Riboflavin (mg/100g)} = \frac{C_s \times V_i \times D}{10} \times \frac{1000}{w_s \quad 10}$$

C_s = concentration of riboflavin in the sample (mg/100g) obtained from regression equation.

D = Sample dilution

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V_i = Initial volume

W_s = Sample weight (g)

Determination of Vitamin B_3 (Niacin)

Vitamin B_3 content was determined by the method described by AOAC (2010). Two (2 g) gram of the pepper sample was weighed into a 500 mL blender jar (the sample weight was enough to contain 0.04mg niacin). It was followed by addition of 198 mL water and 10 g Calcium hydroxide. Standard treatment was prepared and treated with 10 g Calcium hydroxide. The samples and standard were blended approximately 30 seconds at high speed using a vertical blender, autoclaved 15 minutes at 121^0C and cooled in ice bath for at least 30 min. The extract was transferred to a 250 mL volumetric flask and brought to volume with water. The cold solution was filtered through Whatman paper No: 2v, and supernatant filtered. The solution was centrifuged to help clear the filtrate. Exactly 100 mL of the filtrate was transferred, measured with volumetric pipette to 250 mL Erlenmeyer flask containing 300mg oxalic acid to adjust pH to 6.5 to 7.0. C_{18} cleanup cartridge was conditioned with 10 mL ethanol and then passed through 10mL water. A 10 mL of clear sample filtrate was slowly passed through the cartridge, the first 6 mL was discarded and the next 3.5 mL was collected in sample vial. One drop of 85% Phosphoric acid (H_3P_{04}) was added and mixed well. One hundred (100) mL standard acid sample solutions were injected using the standard chromatographic conditions. Niacin was calculated using standard curve procedure stated as follows:

$$\text{Niacin mg/100} = \frac{C_s \times V_i}{W_s}$$

Where

C_s = Concentration of niacin in the sample (mg/100g) obtained from regression equation

V_i = Initial volume (mL)

W_s = Sample weight (g)

Determination of Vitamin B_6 (Pyridoxine).

Vitamin B_6 content was determined by the method described by AOAC (2010). Each dried and fresh sample (2.5g) of the pepper was weighed in each of the two 200 mL E-flasks analyzed as duplicates respectively to ensure precision. Extraction media (50 mL 0.1 M HCl) was added and sample was autoclaved for 5minutes at 121^0C and cooled to 25^0C in water. The pH was adjusted to 4.5-0.1 with 2 m Sodium acetate. The sample was quantitatively transferred to a 100 mL volumetric flask and diluted with $MQ^{(R)}$ water. The extract was filtered (0.45µm Munktel V120H) and two aliquots of 2.5 mL of the extract was transferred to 10 mL volumetric flasks. Acid phosphatase (25 units/ mL 200 mL) and beta-glucosidase (45 units/ mL, 600 mL) were added to the other volumetric flask. The flask was closed and incubated for 18h at 45ºC. The sample was cooled by adding 1 mL of 1M HCl and filtered with 0.01m HCl to 10 mL. Whatman rotrand 0.2 µm (Cellulose acetate membrane and polycarbonate housing) and transferred to a HPLC-vial. Stock solutions of pyridoxal, hydrochloride, pyridoxine hydrochloride and pyroxamine dihydro chloride served as calibration samples and were prepared with the concentration 10 µg/1 mL and stored for up to two months.

The concentration was controlled by UV absorption (gamma max 288 nm pyridoxal gamma Max 290nm pyridoxine and gamma max 293 nm pyroxamine) and the expected absorbance for pyridoxal is 0.425 Au, pyridoxine 0.45 Au and pyroxamine 0.374 Au. The correction factor was determined by measured absorbance and must be $\geq$ expected absorbance 0.95 nm for the calibration solution to be fit for use. The calibration samples were diluted with 0.01m HCL to concentrations of 5,25 and 100mg/ mL and transferred to HPLC-Vials. Isocratic HPLC was carried out on a C_{18} reverse phase column (phenomerex kinetex 2.6m 150 x 4.6 nm) with an auto sampler to inject 50 mL. The samples were kept in dark at 50^0C during analysis. The column was equipped with a column saver, 0.5 µm. The HPLC buffer (pH 2.75) consisted of 2.2mM octanusulfonic acid,

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81mM di-potassium hydrogen phosphate, 19mM 0-phosphoric acid and 10 mM trimethylamine the buffer was filtered through a 0.45 µm Millipore filter. The mobile phase was prepared with a 4 percent (v/v) acetonitrile grade HPLC in HPLC buffer. The mobile phase was run at 0.7 mL/min. The column oven was held at 25^0C.

To improve the detection, a post-column buffer was prepared by regulating pH in a 0.5m di-Potassium hydrogen phosphate solution to 7.5 ± 0.1 with o.5m Potassium dihydrogen phosphate. The buffer was added post-column at 0.3 mL /min. The vitamins were detected by florescence detector, with excitation at 333 nm and emission at 775 nm. Each sample was run 20 minutes.

Vitamin B_6 is presented as total pyridoxide including vitamers PL, PN and PM. Glycosylated pyridoxine is calculated as a difference between free pyridoxine (all vitamers except the glycosylated pyridoxine) and total pyridoxine. Duplicates were calculated as an average. To compensate for the difference in molecular weight between the vitamers, it was calculated according to PN = [PN]+(0.85X[Pm]+(1.01x[PL]] thereby presented as pydoxine hydrochloride. Pyridoxine was calculated as 0.825mg corresponding to the molecular weight of 1mg pyridoxine hydrochloride.

Mineral Content Determination.

The minerals in the pepper samples were determined from solution obtained when 5 g of the samples were digested with 10 mL of 5N concentrated hydrochloric acid (HcL). The mixtures were placed on an water bath and evaporated almost to dryness. The solution was cooled and filtered into 100 mL standard flask and diluted to volume with distilled water. Atomic absorption spectrophotometer was used to analyse the minerals separately after acid digestion of samples as described in the Official method of association of Official Analytical Chemist (AOAC, 2010)

Determination of Potassium (K)

About 5 mL of the sample was pipette into a test tube in duplicate. Then 2 mL of colblanitrite was added, shaken vigorously and allowed to stand for 45 min and centrifuged for 15 min. the supernatant was drained off and 2 mL of ethanol was added to the residue. The solution was shaken vigorously and centrifuged for another 15 min. the supernatant was drained off and 2 mL of distilled water was added to the residue. The solution was boiled for 10 min with frequent shaking to dissolve the precipitate. About 1 mL of 1% choline hydrochloride and 1 mL of 2% sodium cyanide was added. 2 mill of distilled water was also added and the solution was shaken to mix well. The absorbance was taken at 768 against the blank.

$$\text{Potassium mg/ 100g} = \frac{\text{ppm found from standard curve x Volume made up x Dilutions if any x 100}}{\text{Weight of sample x 1000}}$$

Determination of Sodium (Na)

An aliquot of pepper extract AOAC (2010) was diluted so that it contained less than 10 ppm of sodium. Sufficient HCl was added so that the concentration of acid was the same as that in the standard solution. The diluted extract was atomized in a calibrated flame photometer with the wavelength dial set at 589 nm and the transmittance at 100% for the top standard solution. A standard curve of concentration against percent luminosity of sodium was made.

$$\text{Sodium mg/100g} = \frac{\text{ppm found from the standard curve x volume made up x Dilution x 100}}{\text{Weight of sample x 1000}}$$

RESULTS AND DISCUSSIONS

Results of the evaluation of mineral and vitamin content of pepper samples are presented in Table 3.

Table 3: Results of Mineral Vitamin Constituents of 'Nsukka' Yellow Pepper samples

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Expt. No.	Expt. Run	Oil concentration (%)	Blanching time (min)	Drying Temperature (^{0}C)	Sodium (mg/100g)	Potassium (mg/100g)	Vitamin B_2 (mg/100g)	Vitamin B_3 (mg/100g)	Vitamin B_6 (mg/100g)	Vitamin C (mg/100g)
1	11	3	2	50	119.46^{i}±0.170	849.37^{f}±0.438	3.82^{d}±0.014	3.43^{f}±0.035	1.25^{b}±0.042	2.79^{d}±0.035
2	9	10	2	50	116.20^{k}±0.078	624.11^{l}±0.488	1.16^{k}±0.028	1.84^{ij}±0.099	0.34^{h}±0.021	2.73^{de}±0.042
3	2	3	5	50	276.40^{a}±0.792	669.86^{i}±0.205	4.50^{c}±0.028	3.80^{de}±0.028	1.94^{a}±0.057	2.78^{d}±0.028
4	5	10	5	50	169.33^{d}±0.544	1036.50^{b}±3.536	2.62^{f}±0.064	8.00^{b}±0.042	1.27^{b}±0.014	3.44^{c}±0.000
5	4	3	2	90	218.42^{c}±0.276	633.29^{k}±0.530	0.97^{l}±0.035	3.46^{f}±0.021	0.85^{e}±0.042	2.55^{f}±0.035
6	15	10	2	90	126.85^{h}±0.290	1153.23^{a}±1.195	0.38^{n}±0.028	2.38^{h}±0.141	0.26^{i}±0.021	2.79^{d}±0.042
7	1	3	5	90	118.25^{j}±0.042	672.95^{h}±0.071	2.40^{h}±0.021	0.90^{k}±0.064	0.16^{j}±0.028	2.61^{ef}±0.219
8	13	10	5	90	96.78^{m}±0.262	794.39^{g}±0.375	6.11^{b}±0.035	4.06^{c}±0.071	0.33^{h}±0.028	2.11^{g}±0.064
9	19	0.61	3.5	70	157.28^{e}±0.205	643.84^{j}±0.389	2.71^{e}±0.021	2.85^{g}±0.021	0.56^{g}±0.000	2.82^{d}±0.028
10	16	12.39	3.5	70	137.42^{g}±0.820	611.12^{m}±1.584	2.49^{g}±0.042	3.91^{cd}±0.057	ND	3.47^{c}±0.042
11	6	6.5	0.98	70	151.48^{f}±0.516	593.19^{n}±1.358	1.32^{i}±0.014	3.74^{e}±0.099	ND	4.14^{b}±0.021
12	12	6.5	6.02	70	102.80^{l}±1.160	971.59^{c}±0.156	6.19^{a}±0.042	8.26^{a}±0.120	0.92^{d}±0.028	2.75^{d}±0.014
13	8	6.5	3.5	36.36	96.62^{m}±0.028	901.61^{e}±2.277	0.19^{o}±0.005	1.69^{j}±0.057	1.18^{c}±0.064	2.77^{d}±0.014
14	7	6.5	3.5	103.64	250.06^{b}±0.325	949.93^{d}±01.485	0.79^{m}±0.035	3.31^{f}±0.028	0.77^{f}±0.021	2.62^{ef}±0.028
15	17	6.5	3.5	70	119.28^{ij}±0.198	306.97^{p}±1.025	1.25^{j}±0.035	1.89^{i}±0.078	0.09^{k}±0.003	1.40^{h}±0.028
16	20	6.5	3.5	70	119.28^{ij}±0.198	306.97^{p}±1.025	1.25^{j}±0.035	1.89^{i}±0.078	0.09^{k}±0.003	1.40^{h}±0.028
17	18	6.5	3.5	70	119.28^{ij}±0.198	306.97^{p}±1.025	1.25^{j}±0.035	1.89^{i}±0.078	0.09^{k}±0.003	1.40^{h}±0.028
18	14	6.5	3.5	70	119.28^{ij}±0.198	306.97^{p}±1.025	1.25^{j}±0.035	1.89^{i}±0.078	0.09^{k}±0.003	1.40^{h}±0.028
19	10	6.5	3.5	70	119.28^{ij}±0.198	306.97^{p}±1.025	1.25^{j}±0.035	1.89^{i}±0.078	0.09^{k}±0.003	1.40^{h}±0.028

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20	3	6.5	3.5	70	119.28^{ij} ±0.198	306.97^{p}±1.025	1.25^{j}±0.035	1.89^{i}±0.078	0.09^{k}±0.003	1.40^{h}±0.028
FNYP					35.39^{n}±0.460	348.43^{o}±0.141	0.05^{p}±0.004	0.39^{i}±0.028	0.26^{i}±0.004	10.68^{a}±0.042

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

FNYP = Fresh 'Nsukka' Yellow Pepper

Values obtained for sodium ranged from 96.62 - 276.40 mg/100g. Sample with oil concentration of 3%, blanching time of 5 min and drying temperature of 50^0C (experiment 3) had the highest sodium content while sample with oil concentration of 10% blanching time of 5 min and drying temperature of 90 ^{0}C (experiment 8) had the lowest value. No significant differences ($p \geq 0.05$) existed among most of the samples. The sodium values obtained from this study are higher than 13.8 - 14.4 mg/100g range values obtained from Capsicum varieties by Esayas et al. (2011). Again the values are higher than 22 mg/100g obtained from Capsicum annum by Sharma et al. (2017). The values are also higher than 1.66 mg/100g obtained from dried Capsicum annum by Emmanuel-Ikpeme et al. (2014). The experimental values are also higher than 74.55 mg/100g value obtained from Capsicum annum by Ogunlade et al. (2012). The values are higher than 30 – 71 mg/100g obtained from powdered Capsicum annum by Al-Snafi (2015). One may attribute the high sodium content to oil treatment of the samples used for the study and concentration of the sodium by drying process. Since even the fresh pepper sample had lower value (35.39 mg/100g).

Results obtained for potassium ranged from 306.97 - 1153.23 mg/100g. Sample with oil concentration of 10%, blanching time of 2 min and drying temperature of 90^0C (experiment 6) had the highest potassium 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. Significant differences ($p \leq 0.05$) existed among most of the samples. The results obtained are higher compared to 89.25 mg/100g obtained from Capsicum annum by Ogunlade et al. (2012). The values are close to 324.21 mg/100g obtained from Capsicum annum by Emmanuel-Ikpeme et al. (2014). However, the values are lower than 6925 mg/100g obtained from Capsicum annum by Sharma et al. (2017). The values are also lower than 2168 -2523 mg/100g range values obtained from Capsicum annum and Capsicum frutescens grown in Iraq by Al-Snafi (2015). Potassium plays an important role in neurotransmission; regulation of heart beat and maintains water balance in the human body. It is also an important nutrient and has a significant role in the synthesis of proteins and amino acids. High amount of potassium in the body increases utilization of iron and helpful for people using diuretics to prevent hypertension, and those suffering from too much excretion of potassium through the body fluid (Khan et al., 2019).

Sodium values obtained from the treated samples used in this study are very high which could limit their utilization as condiment for food preparation. It is however interesting to note that Na/K ratios of the samples when calculated are less than 1. This suggests that treated and dried 'Nsukka' yellow pepper samples are very suitable as condiments in the preparation of diets for hypertensive patients (Ogunlade et al., 2012). It is better to look at these two minerals together (Na – K ratio) since they work in tandem throughout the body. WHO (2012) recommended Na/K to be approximately equal to 1

Values obtained for vitamin B_2 (Riboflavin) ranged from 0.19 to 6.19 mg/100g. Sample with oil concentration of 6.5%, blanching time of 6.02 min and drying temperature of 70 ^{0}C (experiment 12) had the highest vitamin B_2 value while sample with oil concentration 6.5 blanching time of 3.5 min and drying temperature of 36.36 ^{0}C (experiment 13) had the least value. Significant differences ($p \leq 0.05$) existed among the samples. The values obtained are higher than the 0.017mg/100g value reported by Syeda et al. (2015). Vitamin B_2 values are also higher than 0.028mg/100g reported by USDA (2016) for Capsicum annum . The values are however lower than 1.1 -1.3 mg/100g required for adult (Institute of Medicure, 1998). High values obtained from this study could be due to minimal loss of the vitamin during drying process. The loss is less because as drying proceeds, Riboflavin becomes supersaturated and precipitates (Fellows, 2009).

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Values obtained for vitamin B_3 (niacin) ranged from 0.90 to 8.26 mg/100g. Sample with oil concentration of 6.5%, blanching time of 6.02 min and drying temperature of 70 ^{0}C (experiment 12) had the highest vitamin B_3 value, while sample with oil concentration 3% blanching time of 5 min and drying temperature of 90 ^{0}C (experiment 7) had the least value. Significant difference ($p \leq 0.05$) existed among the samples. Values obtained from dried samples are higher than 0.39 mg/100g value obtained from the fresh 'Nsukka' yellow pepper (FNYP) sample. The experimental values are also higher than 0.157mg/100g value reported by Syeda (2015) for Capsicum annum and 0.66mg/100g value given by Cengage (2007) for pepper. The values are also higher than 0.68mg/100g obtained by Emmanuel-Ikpeme et al. (2014) in pepper varieties. The values are however lower than 14 – 16 mg/100g required daily for adults (Institute of Medicine, 1998).

Vitamin B_6 (pyridoxine) values ranged from 0.09 to 1.94 mg/100g. Vitamin B_6 could not be detected in experiments 10 and 11. Sample with oil concentration of 3%, blanching time of 5 min and drying temperature of 50 ^{0}C (experiment 3) had the highest vitamin B_6 value while sample with oil concentration 6.5% blanching time of 3.5 min and drying temperature of 70 ^{0}C (experiment 15-20) had the least value. Significant differences ($p \leq 0.05$) existed among most of the samples. the value of 0.26 mg/100g of vitamin B_6 obtained from the fresh sample (FNYP) fell within the range values obtained from dried samples. Vitamin B_6 from study are higher than 0.037mg/100g reported by Syeda (2015). Values obtained conform with the 0.12 mg/100g and 0.31 mg/100g reported by Emmanuel-Ikpeme et al. (2014) and Cengage (2007), respectively. But the values reported in this study are lower than 1.2 – 1.3 mg/100g daily requirement for adult. Low value of vitamin B_6 reported could be due to degradation of the vitamin during drying process by heat (Arifin and Djaeni, 2017). Vitamin B_6 loss is usually by reaction with sulphydryl groups of proteins and amino acids when heated or during storage. Vitamin B_6 is difficult to assay (Fellows, 2009), this may be the reason it could not be detected in some samples.

Values obtained for vitamin C (ascorbic acid) ranged from 1.40 to 4.14 mg/100g. Sample with oil concentration of 6.5%, blanching time of 0.98 min and drying temperature of 70 ^{0}C (experiment 11) had the highest vitamin C content 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. Many of the samples are not significantly different ($p \geq 0.05$) from each other. The ascorbic acid content of 10.68 mg/100g obtained from the fresh samples (FNYP) is higher than values obtained from the dried samples confirming loss during processing. The ascorbic content of the studied samples is low compared to 47.55 mg/100g obtained from Capsicum annum dried at 60^{0}C by Emmanuel-Ikpeme et al. (2014). The values are also low when compared to 172.20 - 177.67 g/100g from Capsicum chinenses dried at 55- 65^{0}C range obtained by Reis et al. (2013). Again the vitamin C content of samples studied are lower than 101.19 - 167.54 mg/100g obtained from varieties of Capsicum annum by Perucka and Materska (2007), 80.6mg/100g reported by Olatunji and Afolayan (2018), 1360.2 - 2020 mg/100g reported by Al-Snafi (2015), 341 mg/100g given by Cengage (2007), 38.02 -49.31 from Chilli dried at 50 -120^{0}C range by Wiriya et al. (2009), 15.29 - 18.58mg/100g obtained from chilli pepper dried at 60-80^{0}C temperature range by Silva et al. (2018) and 80.6mg/100g standard reference by USDA (2016).

Low values of vitamin C obtained from this work is likely to be caused by blanching and drying treatments. Vitamin C is soluble until the moisture content of the food falls to very low level and react with solution at higher rates as drying proceeds (Fellows, 2009). It is also speculated that vitamin C may have been oxidized as drying proceeded leading to the formation of L- dehydro ascorbic acid and a wide variety of carbonyl and other unsaturated compounds. The low ascorbic acid may have been as a result of species of yellow pepper because even the fresh sample had low vitamin C content (10.68 mg/100g). Low vitamin C content of the dried pepper samples confirms Bosland and Votata (2012) who stated that vitamin C becomes negligible after drying process. It was observed that those samples that had the same oil concentration and blanching time but different drying temperatures had significantly different vitamin C values, with those dried under higher temperatures exhibiting lower vitamin C values. This suggests that drying temperature had a significant effect on the vitamin C content.

Dependent Variables and their Predictive Model Equation

Summary of the estimated regression coefficient for dependent variables (potassium, vitamin B_2, B_3, B_6 and

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vitamin C) are shown in Table 4

Table 4 ANOVA Values Response Surface Quadratic Models for minerals and Vitamins

Minerals/Vitamin	**Std. Dev**	**Mean**	**C.V (%)**	**Press**	**R^2**	**Adj. R^2**	**Predic R^2**	**Adeq Prec.**	**P. Value**	**P –Lack of Fit**	**Significant Model**
Sodium	44.82	143.23	31.29	11533 3.90	0.44	0.19	-1.46	5.07	0.192029 (Not significant)	$9.06x10^{-06}$ Significant	-
Potassium	145.43	647.20	22.47	17992 212	0.85	0.72	-0.25	6.19	0.003773 (Not significant)	$5.31x10^{-09}$ Significant	Quadratic
B_2	0.56	2.16	25.80	25.78	0.95	0.90	0.55	14.8	$3.26x10^{-05}$ (Significant)	$6.24x10^{-05}$ Significant	Quadratic
B_3	0.92	3.13	29.25	64.00	0.88	0.78	0.11	9.73	0.001275 (Significant)	$6.63x10^{-07}$ Significant	Quadratic
B_6	0.23	0.52	43.71	3.95	0.91	0.83	0.32	10.44	0.000369 (Significant)	$9.14x10^{-06}$ Significant	Quadratic
Vit..C	0.44	2.45	17.86	14.86	0.84	0.70	-0.21	6.47	0.004824 (Significant)	$2.42x10^{-05}$ Significant	Quadratic

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

Experimental values were obtained for individual responses Y for the design points. Regression coefficients were obtained by employing a least squares technique to predict quadratic polynomial models for the response Y. The quadratic regression models for the influenced variables as shown above are presented as follows:

$$\text{Potassium} = 306.58 + 53.29x_1 + 40.28x_2 + 11.37x_3 + 24.18x_1x_2 + 62.50x_1x_3 - 69.01x_2x_3 + 112.86x_1^2 + 167.63x_2^2 + 218.32x_3^2$$

$$\text{Vit } B_2 = 1.24 - 0.13x_1 + 1.28x_2 - 0.09x_3 + 0.64x_1x_2 + 0.96x_1x_3 + 0.63x_2x_3 + 0.56x_1^2 + 0.97x_2^2 - 0.19x_3^2$$

$$\text{Vit } B_3 = 1.85 + 0.47x_1 + 0.97x_2 - 0.26x_3 + 1.25x_1x_2 - 0.07x_1x_3 - 0.93x_2x_3 + 0.42x_1^2 + 1.35x_2^2 + 0.11x_3^2$$

$$\text{Vit } B_6 = 0.09 - 0.22x_1 + 0.19x_2 - 0.28x_3 + 0.13x_1x_2 + 0.15x_1x_3 - 0.28x_2x_3 + 0.11x_1^2 + 0.17x_2^2 + 0.35x_3^2$$

$$\text{Vit C} = 1.43 + 0.10x_1 - 0.17x_2 - 0.12x_3 - 0.00x_1x_2 - 0.11x_1x_3 - 0.17x_2x_3 + 0.50x_1^2 + 0.61x_2^2 + 0.38x_3^2$$

X_1, X_2 and X_3 are the coded values for oil concentration, blanching time and drying temperature respectively.

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The coefficients with one factor represent the effect of the particular factor, while the coefficients with two factors and those with second order terms represent the interaction (behaviour of one factor may be dependent on the level of another factor) between the two factors and quadratic effect respectively. The positive sign in front of the terms indicates synergistic effect, while negative sign indicates antagonistic effect (Filli et al., 2010).

OPTIMIZATION

Optimization was based on significant regression models ($P < 0.05$), high Adj-R^2 values ($P \geq 0.70$) of the

parameters (Potassium, Vitamin B_2, B_3, B_6, Vitamin C) regardless of significant lack of fit ($P < 0.05$) values for Vitamin B_2, B_3, B_6, Vitamin C and Potassium (Table 4.15). Though Myers et al. (2009) reported that if a model has a significant lack of fit ($P<0.05$), it is not a good indicator of the response and should not be used for prediction. However, Box and Draper (1987) pointed out that when a large amount of data was obtained in analysis, a model with significant lack of fit can still be used, since high Adj. R^2 and significant p-values were considered as evidence of applicability of the regression models. Also, Goos (2012) stated that statistically significant lack of fit might have little impact on the interpretation of data and can be effectively ignored. The description of fitted model for optimized parameters are presented in Table 5

Table 5: Description of fitted model for optimized parameters

Minerals/Vitamin	**Adj. R^2**	**Probability of other values for the quadratic model**	**P –Lack of Fit**
Potassium	0.72 (72%)	0.0038	$5.31x10^{-09}$ Significant
B_2	0.90 (90%)	$3.26x10^{-05}$	$6.24x10^{-05}$ Significant
B_3	0.78 (78%)	0.0013	$6.63x10^{-07}$ Significant
B_6	0.83 (83%)	0.000369	$9.14x10^{-06}$ Significant
Vit..C	0.70 (70%)	0.004824	$2.42x10^{-05}$ Significant

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

Optimization procedure was conducted by maximizing potassium, vitamin B_2, Vitamin B_3, Vitamin B_6 and vitamin C. sodium was not used from optimization because its regression model was not significant and their Adj-R^2 values is low. The optimum values of processing conditions for production dried 'Nsukka' yellow pepper are presented in Table 6

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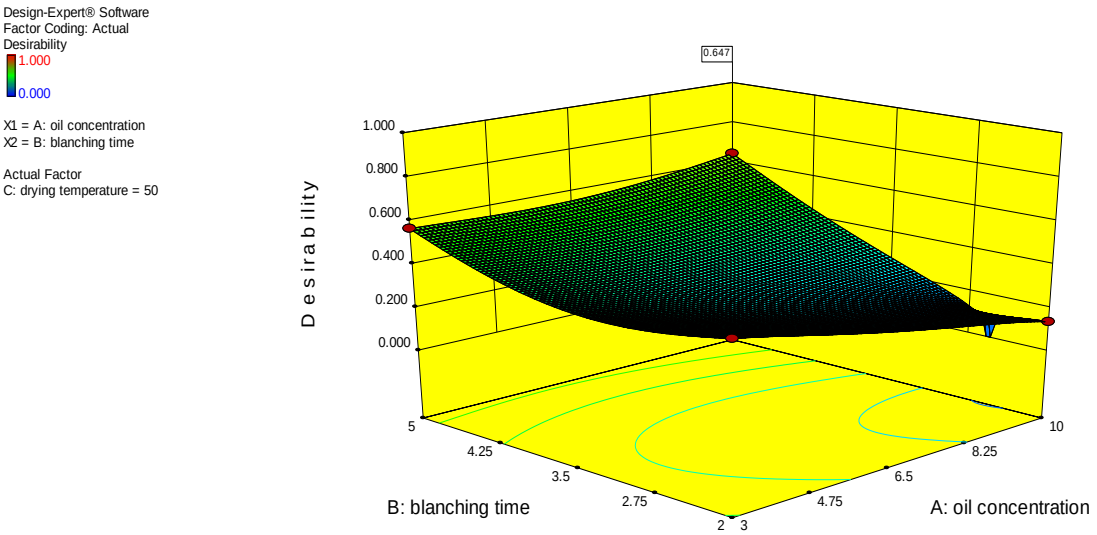
Table 4.16: Optimum Values of Processing Conditions for Production of Dried 'Nsukka' Yellow Pepper

Solution number	Oil conc (%)	Blanching Time (min)	Drying temp (^{0}C)	Potassium (mg/100g)	Vit B_2 (mg/100g)	Vit B_3 (mg/100g)	Vit B_6 (mg/100g)	Vit C (mg/100g)	Desirability
1	10	5	50	918.28	2.87	7.68	1.24	3.26	0.65

Table 6 revealed that 10% oil concentration, 5 min blanching time and 50^{o}C drying temperature will result in dried 'Nsukka' yellow pepper with 918.28mg/100g potassium, 2.87mg/100g vitamin B_2, 7.68mg/100g vitamin B_3, 1.24mg/100g vitamin B_6 and 3.26mg/100g vitamin C. This oil concentration, blanching, time and drying temperature had a desirability function of 0.65. All the drying condition variables were located within the range of experimental values of the independent variables; hence the fitted response equations were adequate for depicting response near stationary point. The 3D surface contour plot generated as a result of optimization is shown in figure 1

Fig. 1: Optimization contour graph



CONCLUSION

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 nutritional composition of `Nsukka' yellow pepper (Capsicum annum L). The ideal drying conditions for the study was 10% oil concentration, 5 min blanching time and 50^{o}C Drying Temperature. This ideal processing condition gave dried pepper with 918.28mg/100g potassium, 2.87mg/100g vitamin B_2, 7.68 mg/100g, Vitamin B_3, 1.24mg/100g Vitamin B_6, 3.26mg/100g Vitamin C. The above parameters were generated from optimization procedure using the ideal condition where the nutrients were maximized, apart from sodium. 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. Concentration of some of the vitamin B_2, B_3, B_6 and potassium increased indicating that 'Nsukka' yellow pepper is their good source. There was tremendous decrease in vitamin C (ascorbic acid) indicating that this vitamin is highly water soluble and heat labile

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