Acta Scientific AGRICULTURE (ISSN: 2581-365X)

Volume 7 Issue 9 September 2023

Editorial

Effect of Three Drying Methods (Oven, Solar and Sun) on the Phytochemical Properties and Bioactive Compounds of Ethiopian Pepper (*Xylopia aethiopica*)

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Received: May 05, 2023

Published: August 02, 2023

Abstract

The study was conducted at the department of horticulture, KNUST to determine the effect of oven, solar and sun drying methods on the phytochemical properties and bioactive compounds of the Ethiopian pepper. A completely randomized design (CRD) with three replications was used. The quality attributes analyzed were proximate composition, quantitative and qualitative properties. oven dried Ethiopian pepper had significantly ($p \leq 0.01$) lower moisture and increased fat, ash, carbohydrate and crude fibre content of 6.5%, 24%, 4.13%, 59.75%, and 33.18% respectively. Solar and oven dried Ethiopian pepper had significantly higher ($p \leq 0.01$) of anti-nutritional components; tannins (3.23%), saponin (3.750) and oxalate (0.29%). The minimal destruction of the essential element of the dried Ethiopian pepper with the use of oven and solar drying methods and the retention of its antioxidants even after drying makes them the best drying methods to use in processing the pepper.

Keywords: Phytochemical Chloroformic; Cyanogenic; Anti-Nutritional and Phlobatannin

Introduction

Ethiopian pepper (Xylopia aethiopica) known in Akan as Hwentia is an evergreen, aromatic tree, of the Annonaceae family that can grow up to a 20m high. It is a native to the lowland rainforest and moist fringe forest in the savanna zones of Africa. The fruits are used as a spice and an herbal medicine containing 5 - 8 seeds. They have constrictions along their length, with each segment pods much smaller and are indehiscent.

The fruit contains monoterpenes (organic compounds) which impart the spiciness onto them, an infusion of the fruits has been useful in the treatment of bronchitis and dysenteric conditions, or as a mouthwash to treat toothaches. The fresh and dried fruits, leaf, stem bark and root bark essential oils show various degrees of activity against several bacteria and certain fungi [24,25].

It has also been used as a medicine for biliousness and febrile pains. The oil has also been used as a mosquito repellent [3]. It has antioxidant properties, and the principal constituents are mono- and sesqui-terpene hydrocarbons. The tree contains annonacine (an alkaloid), volatile aromatic oils [7], diterpenic and xylopicacids [26]. Xylopia aethiopiaca also contains substances such as zinc, lipids, proteins, carbohydrates, iodine, saturated and unsaturated fatty acids, mono- and sesqui -terpenoids, and pinenes, myriene, p.cymene, limonene, linalool and 1, 8, cineole.

The plant is widely distributed in the West African rainforest from Senegal to Sudan in Eastern Africa, and down to Angolain Southern Africa [5,17] where it is mostly used for local cooking, especially in the preparation of what is referred to as 'the African pepper soup [7]. The bark when steeped in palm wine, is used to treat asthma, stomach-aches and rheumatism. The control and monitoring of conditions in the traditional drying methods is difficult especially during the raining season.

Research by Madhlopa., *et al*. [19] and Kingsly., *et al*. (2010) indicated that sun drying exposes fruits to direct sun, wind and microbes, leading to loss of essential bioactive compounds of the fruit. The Nutritional and phytochemical properties of fruit are also affected as a result of the transformations that take place during dry-

ing. Also, prolonged drying may institute some changes that could negatively affect some functional properties of the product. There is little information on the processing of Ethiopian pepper by farmers which they only adopt to the traditional sun drying method, which sometimes unhygienic and time consuming. Alternative drying methods are required to supplement the traditional drying methods to maintain some desirable characteristics in the fruit.

This research work will help to know the appropriate drying methods which would still maintain the active nutritional content of the fruits. However, the effect of the drying methods on the phyto-chemicals of Ethiopian Pepper has not been sufficiently investigated. It is therefore necessary to identify appropriate, easy and cost - effective drying methods. The research, therefore, sought to determine the effect of three drying methods (oven, sun and solar) on the Phytochemical of Ethiopian pepper.

Material and Methods

Experimental site

The experiment was conducted at the laboratories of the Department of Horticulture and Department of Pharmacy, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi.

Source of Ethiopian pepper

Ethiopian pepper was obtained from an out-grower farms at Atobiase in the Bosomtwe District of the Ashanti region. Physiologically matured fruits were harvested and 300g of the fruit sample were weighed, it was further divided into 3 sub-samples to be used for the three drying methods (sun, oven and solar driers). Dried fruits were ground into fine powder after which the laboratory analysis was performed.

Figure 1: Freshly harvested Ethiopian pepper.

Drying treatments

Sun drying

Fruits dried in the sun are placed on trays made of screen or wooden dowels. Screens need to be safe for contact with food. The best screens are stainless steel, teflon coated fiberglass or plastic. Avoid screens made from "hardware cloth". This is galvanized metal cloth that is coated with cadmium or zinc. These materials can oxidize, leaving harmful residues on the food. Also avoid copper and aluminum screening. Copper destroys vitamin C and increases oxidation. Aluminum tends to discolor and corrode. Outdoor drying rack most woods are fine for making trays. However, do not use green wood, pine, cedar, oak or redwood. These woods warp, stain the food or cause off-flavors in the food. Place trays on blocks to allow for better air movement around the food. Because the ground may be moist, it is best to place the racks or screens on a concrete driveway or if possible, over a sheet of aluminum or tin. One hundred grams (100g) of fresh Xylopia fruits were put on a metallic tray and placed on a table directly under the sun light for 7 days. It was constantly stirred to ensure even drying and uniformity. Temperature and humidity were recorded for the 7-day period and the mean value recorded.

Figure 2: Sun dried Xylopia fruits

Solar drying

Recent efforts to improve on sun drying have led to solar drying. Solar drying also uses the sun as the heat source. A foil surface inside the dehydrator helps to increase the temperature. Ventilation speeds up the drying time. Shorter drying times reduce the risks of food spoilage or mold growth. One hundred grams (100g) of fresh Xylopia fruits were put on a metallic tray and placed in the solar dryer for 7 days. It was constantly stirred to ensure even drying and uniformity. Temperature and humidity were recorded for the 7-days period and the mean value recorded.

Oven drying

One hundred grams (100g) of fresh Xylopia fruits were put on a clean metallic tray and placed in the oven to dry at 60 ◦ C within 24 hours.

Figure 3: Solar dried Xylopia fruits.

Figure 4: Oven dried Xylopia fruits.

Parameters studied

Moisture content

The moisture was determined by weighing two grams each of the samples into an already weighed moisture can. The samples were then dried in the oven at 60 ◦ C for 24 hours as the method described by Amadi., *et al*. [4]. After drying they were put into the desiccator and allowed to cool after which it was reweighed. Drying continued until a constant weight was obtained. The moisture was calculated as the difference in weight of the original sample in percentage.

Calculations

(A + B) - A = B (A + B) - (A + C) = B - C = D

% Moisture = D/B x 100. Where A = crucible wt., B = sample wt., C = dry sample wt., D = moisture wt.

Crude protein

The micro Kjeldahl method described by AOAC (1990) was used for determining the Protein content. Two grams of the sample was weighed into a heating tube after which it was mixed with 10ml concentrated H2SO4. The mixture was heated inside a fume cupboard after the addition of one table spoon selenium catalyst after which it was transferred into distilled water. Equal portion of 10ml 45% NaOH was added after which it was transferred into a Kjeldahl distillation apparatus. Distillation of the mixture was carried out and the distillate was received into a 4% boric acid solution containing 3 drops of methyl red indicator.

A 50ml sample of the distillate was collected and titrated as well. The sample was triplicated and mean calculated. A calculation of the nitrogen content was made after which it was multiplied by a factor of 6.25 to obtain the crude protein content. This was given as:

Percentage Nitrogen = 50(S-B) × 0.019057 × 0.0140× 100

10 × wt. of sample

%P = % N × 6.25

Where S = Titre value

B = Blank (0.20)

% P = Percentage Protein

Ash content

Two grams (2g) each of the samples was weighed into a porcelain crucible of known weight after which it was placed into the muffle furnace for ashing at 550 ◦ C within 3hours as described by AOAC (1990). Ashing was carefully done until samples turned white and were free of carbon. The sample was cooled in a desiccator after ashing to a room temperature and reweighed. The weight of the residual ash was then calculated as:

Calculations

(A + B) - A = B

(A + C) - A = C

% Ash = C/B x 100 where A = crucible weight, B = sample weight, C = ash weight.

Crude fibre

Two grams (2g) of the sample was boiled with a 200ml H_2S0_4 (1.25%) in the presence of 1g asbestos for 30 minutes described by AOAC (1990). The acid mixture was filtered using a muslin cloth placed over a Buchner funnel. The residue was thoroughly washed with boiling water until it was free from acid. The process was repeated using 200ml of 1.25% NaoH after which it was washed with 10ml of 95% ethanol.

The residue obtained was scooped into a clean dried porcelain crucible. It was dried in the oven at 100oC to a constant weight. The dried sample was cooled and reweighed. The difference in weight calculated was used for calculating the percentage crude fibre content from the formula shown below.

Calculation

% crude fibre = A-B x100

where A = wt. of dry crucible and sample C

B = wt. of incinerated crucible and ash, C = sample weight.

Crude fat

Two grams of each sample was loosely wrapped with a filter paper into a thimble containing 120ml petroleum ether after which it was fitted with an already weighed round bottom flask. It was connected to a condenser and a soxhlet extractor over a heating mantle. Reflux was allowed for 3hours undisturbed as described by AOAC (1990).

After the set period, the flask containing the ether and the extracted fat were heated until all ether present evolved. The flask was dried in the oven at 100oC for 10 minutes. The flask was reweighed and the percentage fat content calculated.

Calculation

% Fat = A-B x100

where A = wt. of flask and extracted fat, B: weight of fat; C = sample weight.

Carbohydrate

The carbohydrate was calculated as the nitrogen free extract described by AOAC (1990) by summing up all the proximate parameters and deducting from 100.

Calculation

Nitrogen free Extract (NFE) =100- (m + p + f1 + A +f2)

Where A = ash, f2 = Crude fibre; m = moisture; p = Protein; f1 = Fat

Qualitative test

Alkaloid in Xylopia [14]

A small quantity of the fruit extract of the dried Xylopia fruits was extracted with ammoniacal alcohol, filtered and evaporated to dryness. The residue was extracted with 1% sulphuric acid, filtered and the filtrate rendered distinctively alkaline with dilute Nitric solution. It was then shaken with chloroform and the chloroformic layer of the extract evaporated.

The residue was then dissolved in 1% sulphuric acid and used for the text. 2 drops of the detecting reagent (Dragendorff) was added to the 1% sulphuric acid extract and the colour of the precipitate formed noted.

Glycosides

100mg of the powdered material warm with 5ml of dilute sulphuric acid on a water bath for 2 minutes and filtered. The filtrate was made distinctly alkaline by adding 4 drops of 20% sodium hydroxide solution. 5ml each of Fehlings A and B were added to the filtrate and warmed on a water bath for about 2 minutes and the colour of the precipitate formed noted.

Saponins

5g of the powdered material was shaken with a few drops of water in a test tube, filtered and the filtrate shaken rigorously and allowed to stand for over 5 minutes. The formation of froth upon shaken and persisting for minutes or more indicates the presence of saponins.

Tannins [8]

10g of the powdered material was boiled with 25ml of water for 5 minutes, cooled and filtered and the volume adjusted to 30ml.

To 5ml of the extract, 10 drops of 1% lead acetate solution was added and the colour of the precipitate formed noted.

To 5ml of the extract, 10ml of water is added and 2 to 10 drops of 1% ferric chloride solution was added to the colour of the precipitate formed noted. A blue black precipitated was observed in drops.

Flavanoids [13]

10g of the powdered material was macerated with distilled water and filtered into a flask. A strip of white filter paper as dipped into the filtrate, dried and exposed to ammonia for 30 seconds to observe change in colour. The filter paper was then exposed to fumes of hydrochloric acid until a disappearance of the colour change was observed.

Quantitative test

Phytochemical constituents of xylopia aethiopica

By dissolving 50g of sodium tungstate in 37cm3 of distilled water, folin-Denis reagent was made. To the reagent prepared above, 10g of phosphomelybdic acid and 25cm3 of orthophosphoric acid were added. Two-hour reflux of the mixture was carried out, cooled and diluted to 500cm2 with distilled water. This was boiled gently for 1 hour on an electric hot plate and filtered into 100cm3 volumetric flask. Addition of 5cm Folin-Denis reagent and 10cm3 of saturated sodium tungstate solutions into 50cm3 of distilled water and 10cm3 of diluted extract (aliquot volume) was carried out after being pipetted into a 100cm3 conical flask for colour development.

The solution was allowed to stand for 30 minutes in a water bath at a temperature of 25°C after thorough agitation. With the

aid of a spectrum lab 23A spectrophotometer optical density was measured at 700nm and compared to a standard tannic acid curve.

Dissolution of 0.20g of tannic acid in distilled water and dilution of 200cm3 mark (1mg/cm3) were used to obtain tannic standard curve. Varying concentration (0.2-1.0mg/cm3) of the standard tannic acid solution were pipetted into five different test tubes to which Folin-Denis reagent (5cm3) and saturated sodium tungstate (10cm3) solution were added and made up to the 100cm3 mark with distilled water. The solution was left to stand for 30 minutes in a water bath at 25°C. Optical density was ascertained at 700mn with the aid of a spectrum lab 23A spectrophotometer [8]. The following formula was used in the calculation.

Tannic acid (mg/100g) = (C ×extract volume)/(Aliquot ×weight of sample) ×100

Where C is concentration of tannic acid

Alkaloids [8]

Exactly 200cm3 of 10% acetic in ethanol was added to each of the powdered material (2.5g) in a 250cm3 beaker and allowed to stand for 4 hours. The extract was concentrated on a water bath to one-quarter of the original volume followed by addition of 15 drops of concentrated ammonium hydroxide drop wisely to the extract until the precipitation was complete immediately after filtration.

After 3 hours of mixture sedimentation, the supernatant was discarded and the precipitates were washed with 20cm3 of 0.1M of ammonium hydroxide and then filtered. Using a balance, the residue was dried in an oven and the percentage of alkaloid is expressed mathematically as

%alkaloid = (weight of alkaloid)/(weight of sample) ×100

Flavonoid [8]

Exactly 50cm3 of 80% aqueous methanol was added to 2.5g of sample in a 250cm3 beaker, covered and allowed to stand for 24hours at room temperature. After discarding the supernatant, the residue was re-extracted (three times) with the same volume of ethanol and filtered. Each sample was transferred into a crucible and evaporated to dryness over a water bath. The content in the crucible was cooled in a desiccator and weighed until constant weight was obtained. The percentage of flavonoid was calculated

%Flavonoid = (Weight of flavonoid) / (Weight of sample) ×100

Saponin [8]

Exactly 100cm3 of aqueous ethanol was added to 5g of the powdered material in a 250cm3 conical flask. The mixture was heated over a hot water bath for 4 hours with continuous stirring at a room temperature of 55°C. The residue of the mixture was re-extracted with another 100cm3 of aqueous ethanol after filtration and heated for 4 hours at a constant temperature of 55°C with constant stirring.

The combined extract was evaporated to 40cm separating funnel and vigorously agitated from which the aqueous layer was recovered while the ether layer was discarded. The purification process was repeated twice. 60cm3 of n-butanol was added and extracted twice with 10cm3 of 5% sodium chloride.

After discarded the sodium chloride layer the remaining solution was heated in a water bath for 30minutes after which the solution was transferred into a crucible and was dried in an oven to a constant weight. The saponin content was calculated as a percentage.

%Saponin = (Weight of saponin)/(Weight of sample) × 100

Glycoside [14]

Cyanogenic glycoside quantitative determination methodology was use in this research. Cyanogenic glycoside was weighed into a 250 cm3 round bottom flask and about 200 cm3 of distilled water was added to one gram of each dry wood powder sample and allowed to stand for 2 hours for autolysis to occur. Full distillation was carried out in a 250 cm3 conical flask containing 20 cm3 of 2.5% NaoH (sodium hydroxide) in the sample after adding an antifoaming agent (tannic acid). Cyanogenic glycoside (100 cm3), 8 cm3 of 6 M NH4oH (ammonium hydroxide), and 2 cm3 of 5% KI (potassium iodide) were added to the distillate(s), mixed, and titrated with 0.02 M AgNo3 (silver nitrate) using a microburette against a black background. Turbidity which was continuous indicates the end point.

Content of cyanogenic glycoside in the sample was calculated as

Cyanogenic glycoside (mg/100) = Titre volume (cm3) x 1.08 x exact volume x 100

Aliquot volume (cm3) x sample weight (cm3)

Anti-nutritional composition of the xylopia

The anti-nutritional composition of the Xylopia fruit was carried out using different methods. Tannins, Oxelate, Phlobatannins, Saponnin and Salkowski were determine using spedtrophotometric procedure. Flavonoid composition was determined by the method describe by Dye and modified by Iwuoha and Kalu [16].

Data analysis

Data obtained from the laboratory analysis was subjected to Analysis of Variance (ANOVA) using STATISTIX version 9. The differences in means were separated using Tukeys Honesty significant difference (HSD) at 1%. The results were then presented in tables.

Results and Discussion

Effects of different drying methods on the proximate composition of the xylopia

The effects of different drying methods on the proximate composition were presented in table 1. The different drying conditions resulted in significant ($P \leq .01$) variation in the moisture content among the dried Xylopia Fruits which ranged from 6.50% to 12.88%. Solar drying had the highest moisture content (12.88%) with sun drying recording (11.2%) and the least was oven drying recording (6.50%).

There was variation in the values of the proximate composition of the Xylopia fruits and significant differences exist between them. All the fruits that were oven dried recorded highest values for Ash content with sun drying recording the lowest. However, there was no significant difference among the three drying methods in terms of ash content.

However, it was observed that all the fruits that were tested for in-terms of Ash, carbohydrates, Fat and protein content were not significantly ($P > .01$) different from each other in term of the drying method used while they were significantly ($P < .01$) different in the crude fiber content. All the dried fruits that were solar dried were rich in protein and fiber than those that were sun dried and oven dried. Oven and solar drying recorded the highest value of 40.71g/100gDM and 40.10g/100gDM of crude fiber respectfully while oven dried recorded the lowest value of crude fiber of 33.18 g/100gDM.

Drying methods	ASH (%)	CHO (%)	Crude fibre (%)	Fat (%)	Protein (%)	Moisture content (%)
OVEN	4.13a	59.75a	33.18b	24.00a	18.21a	6.50c
SOLAR	3.73a	58.78a	40.10a	20.00a	17.51a	12.88b
SUN	2.54a	59.75a	40.71a	19.50a	18.21a	11.20a
CV (%)	3.46	2.58	5.26	9.45	2.9	0.13
LSD (0.01)	3.63	4.54	6.05	0.05	1.51	0.28

Table 1: Effects of three drying methods on the proximate composition of dried *Xylopia* fruits.

Each value is a mean of three replicates. Standard error of each sample value having the same alphabet as in the same subscripts in the same column are not significantly at LSD (0.01).

Qualitative test for the *Xylopia*

The qualitative compositions of X. aethiopica tested are summarized in Table 2. The results revealed the presence of medically active compounds in all the parts studied. Alkaloids, Saponins, Tannins, flavonoids, and glycosides were tested.

Comparatively, Tannins and Saponins were present in all fruits test with regard to the three drying methods used while flavaniods were absent. In-terms of Glycosides, it was tested positive when dried with oven and solar but negative sign on sun drying method. Both oven and Sun drying methods tested positive for Alkaloids but negative for the use of sun drying methods.

Drying methods	Glycosides	Tannins	Saponins	Flavonoids	Alkaloids
Oven	+	+	+	-	+
Solar	+	+	+	-	-
Sun	-	+	+	-	+

Table 2: Qualitative Analysis of Some Chemical Compounds in Xylopia Aethiopica.

Quantitative test for the *Xylopia*

The quantitative estimation of the chemical is presented in Table 3. Tannins and Glycosides contained very high amount by the use of oven-dry method with saponin (3.6%), alkaloid (4.0%) and flavonoid (4.4%). With solar dry application, Tannins, Alkanoids and saponins recorded the highest value with Flavoniods and Glycosides recording the least value of 3.0% and 4.4% respectfully. This is as a result of prolong drying.

The high amount of Tannins and Glycosides recorded when dried with oven, solar and sun supports the anti-inflammatory, antimicrobial and antitumor activities of X. aethiopica reported by Fleischer (2003). The high amount of Tannins and Glycosides observed in this study therefore accounts for their bitter taste and confirms their numerous therapeutic functions [13].

Reports on the medicinal uses of X. aethiopica by many authors across the globe (Karawya., *et al*., 1979; Fleischer, 2003 [6,17] are fully supported by this work. This is because the plant contains

significant amounts of major active principles of therapeutic benefits. The correlations among the quantified chemicals therefore suggest the multifaceted uses of this plant in curing many types of diseases and ailments.

Drying methods	Tannins	Alkaloids	Flavonoids	Saponins	Glycosides
Oven	10.9 a	4.00 b	4.40 a	3.60 b	5.6 a
Solar	10.6 c	8.80 a	3.17 b	6.80 a	4.4 b
Sun	8.4 b	9.00 a	4.87 a	3.80 b	3.0 c
CV (%)	6.88	1.47	7.06	5.72	2.31
LSD (0.01)	30.27	1.51	0.89	0.82	30.27

Table 3: Quantitative Analysis of Some Chemical Compounds in *Xylopia aethiopica* after Drying.

Each value is a mean of three replicates. Standard error of each sample value having the same alphabet as in the same subscripts in the same column are not significantly at LSD (0.01).

Effects of three drying methods on anti- nutritional components of dried *xylopia*

The effects of different drying methods on the anti-nutritional components of the tested *Xylopia* fruits were presented in table 4. Significant differences occurred among the dried *Xylopia* fruits regardless of the drying methods used. Tannin, oxalate, Saponin, Salkowski, flavonoid and Phlobatannin were the anti-nutritional component observed.

However, Salkowski and flavanoid were absent in all the dried fruits in spite of the drying method used. Sun and solar method were noted to record high value of the anti- nutritional components than those that were oven dried. Solar and sun recorded the highest value of tannin and oxalate regardless of the drying method used. However, sun drying method recorded the highest value of saponin than those that were oven and solar dried. Also, it was noted that all the sun dried, oven dried, solar dried Xylopia had no phlobatannin.

Each value is a mean of three replicates. Standard error of each sample value having the same alphabet as in the same subscripts in the same column are not significantly at LSD (0.01).

Drying Methods	Tannin	Saponin	oxalate	Phlobatannin	Salkowski
Oven	$2.52 \pm .00^{c}$	$2.36 \pm .011^{a}$	$0.18 \pm .1.11^{c}$	$0.00 \pm .00^{a}$	$0.00 \pm .00^{a}$
Solar	$3.23 \pm .00^{b}$	$3.72 \pm .00^{b}$	$0.29 \pm .00^{a}$	$0.00 \pm .00^{a}$	$0.00 \pm .00^{a}$
Sun	$3.31 \pm .00^{a}$	$4.00 \pm .00^{c}$	$0.30 \pm .00^{a}$	$0.00 \pm .00^{a}$	$0.00 \pm .00^{a}$

Table 4: The Effect of three Drying Method on the Anti-Nutritional Components on the Tested Xylopia Fruits.

Discussion

Effect of three drying methods on the proximate composition of xylopia.

Moisture content

In this study the highest moisture removal capability was recorded by oven. Sun and solar drying methods were not as efficient as oven probably due to the low ambient temperature and higher relative humidity. Higher ambient temperatures accompanied by lower relative humidity results in increased drying rate. Consequently, since the oven temperature was higher with lower relative humidity, the Ethiopian pepper fruits dried better in the oven.

Falade and omojola, [11] reported that dried food substances, especially vegetables which have been dried with moisture content less than 15% have longer shelf life. This is because autolytic enzymes are inhibited at low moisture content [18]. Hence for storage purposes, fruits subjected to oven drying may have longest shelf life.

Ash content

The ash in a food constitutes the inorganic mineral elements present to increase free mineral bioavailability. The higher the dry matter content, the higher its ash and vice versa (Ashbell., *et al*., 2000). The lower ash content recorded by the Xylopia subjected to sun and solar as compared to the high ash content of the oven dried fruits may be due to variation in the dry matter. Interactively, the high ash content of the solar dried fruits may increase its mineral content.

Fat content

The low-fat content of dried fruits by solar may be due to the long exposure of the samples to heat and light within the solar drier. This is because heat, light and radiation are factors which decrease fat content through lipid oxidation. The increase in fat content of oven dried fruits may be due to an increase in the dry matter content.

Crude fibre content

Dried Xylopia fruits reported to contain adequate amount of crude fiber and is useful as a fodder for livestock. Fruits dried by sun had highest crude fiber content than those that are dried by oven. This may be due to the complexing of carbohydrate with amino acids under ambient temperature [20] for longer period of time.

The fiber content in fruits as reported by Adanlawo and Ajibade [2] was 4.69%. From the studies, a higher fiber content within the range of 14.48% - 19.54 % was obtained as compared to their report probably due to differences in the method of analysis. Hence for drying interaction, sun dried fruits having the highest fiber (40.71%) may ensure proper peristaltic action in the intestinal tract than oven dried having the least (33.18%) fiber content.

Crude protein content

High protein content subjected to sun drying and oven drying may be due to an increase in the dry matter content [10,12,22]. The lower protein content obtained for solar drying may be due to the prolong exposure of samples to ambient temperature. Protein forms a complex with carbohydrate through Maillard reaction and cause protein denaturation when it is exposed to high temperature.

Carbohydrate content

The high carbohydrate content of fruits dried by oven as compared to that dried by solar and sun may be due to the minimal break down of carbohydrate in the oven dried samples than the two. This is because the time samples took to dry in the oven was less (48 hours) as compared to the time samples took (7days) to dry in the solar and sun drier.

Respiration and metabolic activities within harvested crops are directly related to temperature. This is because high temperature hastens the rate of respiration in harvested or stored food there by breaking down carbohydrate to produce energy [5]. The high carbohydrate content from the study is in agreement with the finding of Ojokoh., *et al*. [23] to provide energy.

Effects of drying on qualitative and quantitative properties

The dried extract of Xylopia aethiopica were used in the study. Preliminary phytochemicals present were quantified using standard procedures. The result of the screening of the samples showed the presence of alkaloids, saponins, flavonoids, tannins and glycosides samples.

The result indicates that flavonoids were tested negative regardless of the drying method used. Tannins and saponins were tested positive. Glycosides recorded positive for both oven and solar drying methods but Alkanoid also recorded positive for oven and sun drying methods but negative for solar drying methods. Tannins and Saponin were significantly ($P < .01$) using the three dry methods. Ekpo., *et al.* did not observe significant ($P > .01$) difference between the flavonoid, Phlobatannin and Salkowski content of the samples. They recommended the plant as a potential source of useful drugs [9].

Anti-Nutritional Component of Ethiopian pepper

The dried fruits contain Tannin, Saponin, oxalate and Phlobatannin out of six anti-nutritional factors tested for. However, it was noted that these elements were greatly reduced by oven drying and sun drying methods with phlobatannin appeared to be most affected.

This work agreed with the work of Abiodun., *et al*. [1] as well as Matazu and Haroun [21] in which sun drying method was found to reduce the composition of these anti-nutritional factors.

SOURCE DF SS MS F P

REP 2 0.0912 0.04560

ACCE 2 10.6080 5.30401 51.76 0.0000

DRM 2 1.0137 0.50685 4.95 0.0213

ACCE*DRM 4 8.4684 2.11710 20.66 0.0000

ERROR 16 1.6397 0.10248

TOTAL 26 21.8210

GRAND MEAN 5.5493 CV 5.77

APPENDIX 1: ANALYSIS OF VARIANCE TABLE FOR ASH.

SOURCE DF SS MS F P

REP 2 0.407 0.203

ACCE 2 314.196 157.098 765.58 0.0000

DRM 2 61.344 30.672 149.47 0.0000

ACCE*DRM 4 70.110 17.527 85.42 0.0000

ERROR 16 3.283 0.205

TOTAL 26 449.340

GRAND MEAN 60.581 CV 0.75

APPENDIX 2: ANALYSIS OF VARIANCE TABLE FOR CARBOHYDRATE.

SOURCE DF SS MS F P

REP 2 0.0403 0.02013

ACCE 2 2.5478 1.27391 24.47 0.0000

DRM 2 12.0573 6.02863 115.82 0.0000

ACCE*DRM 4 5.6963 1.42408 27.36 0.0000

ERROR 16 0.8328 0.05205

TOTAL 26 21.1745

GRAND MEAN 2.0978 CV 10.88

APPENDIX 3: ANALYSIS OF VARIANCE TABLE FOR FAT.

SOURCE DF SS MS F P

REP 2 0.0340 0.0170

ACCE 2 52.6189 26.3094 4102.24 0.0000

DRM 2 10.1335 5.0667 790.02 0.0000

ACCE*DRM 4 33.0787 8.2697 1289.43 0.0000

ERROR 16 0.1026 0.0064

TOTAL 26 95.9677

GRAND MEAN 16.914 CV 0.47

APPENDIX 4: ANALYSIS OF VARIANCE TABLE FOR CRUDE FIBRE.

SOURCE DF SS MS F P

REP 2 0.204 0.1022

ACCE 2 6.088 3.0440 80.19 0.0000

DRM 2 97.409 48.7043 1283.07 0.0000

ACCE*DRM 4 16.670 4.1675 109.79 0.0000

ERROR 16 0.607 0.0380

TOTAL 26 120.978

GRAND MEAN 9.1019 CV 2.14

APPENDIX 5: ANALYSIS OF VARIANCE TABLE FOR MOISTURE CONTENT.

SOURCE DF SS MS F P

REP 2 0.0119 0.0060

ACCE 2 22.6692 11.3346 4737.36 0.0000

DRM 2 0.2076 0.1038 43.39 0.0000

ACCE*DRM 4 10.5459 2.6365 1101.93 0.0000

ERROR 16 0.0383 0.0024

TOTAL 26 33.4728

GRAND MEAN 5.7563 CV 0.85

APPENDIX 6: ANALYSIS OF VARIANCE TABLE FOR PROTEIN.

SOURCE DF SS MS F P

REP 2 0.00010 0.00005

DRM 2 0.26405 0.13203 8911.75 0.0000

ACCE 2 0.13970 0.06985 4714.75 0.0000

DRM*ACCE 4 0.02495 0.00624 421.00 0.0000

ERROR 16 0.00024 0.00001

TOTAL 26 0.42903

GRAND MEAN 2.8937 CV 0.13

APPENDIX 7: ANALYSIS OF VARIANCE TABLE FOR PH.

SOURCE DF SS MS F P

REP 2 0.01115 0.00558

ACCE 2 0.96456 0.48228 137.96 0.0000

DRM 2 0.00307 0.00154 0.44 0.6519

ACCE*DRM 4 0.06996 0.01749 5.00 0.0083

ERROR 16 0.05593 0.00350

TOTAL 26 1.10468

GRAND MEAN 0.7910 CV 7.47

APPENDIX 8: ANALYSIS OF VARIANCE TABLE FOR CALCIUM.

SOURCE DF SS MS F P

REP 2 0.0229 0.0114

ACCE 2 52.2156 26.1078 2595.64 0.0000

DRM 2 2.2467 1.1233 111.68 0.0000

ACCE*DRM 4 14.7394 3.6849 366.35 0.0000

ERROR 16 0.1609 0.0101

TOTAL 26 69.3855

GRAND MEAN 6.3944 CV 1.57

APPENDIX 9: ANALYSIS OF VARIANCE TABLE FOR IRON.

SOURCE DF SS MS F P

REP 2 0.00002 0.00001

ACCE 2 0.02900 0.01450 1048.20 0.0000

DRM 2 0.00799 0.00400 288.87 0.0000

ACCE*DRM 4 0.03683 0.00921 665.62 0.0000

ERROR 16 0.00022 0.00001

TOTAL 26 0.07407

GRAND MEAN 0.5648 CV 0.66

APPENDIX 10: ANALYSIS OF VARIANCE TABLE FOR POTASSIUM.

SOURCE DF SS MS F P

REP 2 0.00003 0.00001

ACCE 2 0.45295 0.22647 18600.1 0.0000

DRM 2 0.04867 0.02434 1998.70 0.0000

ACCE*DRM 4 0.07375 0.01844 1514.30 0.0000

ERROR 16 0.00019 0.00001

TOTAL 26 0.57559

GRAND MEAN 0.3690 CV 0.95

APPENDIX 11: ANALYSIS OF VARIANCE TABLE FOR MAGNESIUM.

SOURCE DF SS MS F P

REP 2 1.250E-05 6.250E-06

ACCE 2 1.263E-03 6.317E-04 28.99 0.0000

DRM 2 2.174E-04 1.087E-04 4.99 0.0207

ACCE*DRM 4 1.478E-03 3.696E-04 16.96 0.0000

ERROR 16 3.487E-04 2.179E-05

TOTAL 26 3.320E-03

GRAND MEAN 0.0225 CV 20.75

APPENDIX 12: ANALYSIS OF VARIANCE TABLE FOR SODIUM.

SOURCE DF SS MS F P

REP 2 0.00021 1.037E-04

ACCE 2 0.01243 6.215E-03 143.57 0.0000

DRM 2 0.00187 9.349E-04 21.60 0.0000

ACCE*DRM 4 0.00320 7.993E-04 18.46 0.0000

ERROR 16 0.00069 4.329E-05

TOTAL 26 0.01840

GRAND MEAN 0.3324 CV 1.98

APPENDIX 13: ANALYSIS OF VARIANCE TABLE FOR PHOSPHORUS.

SOURCE DF SS MS F P

REP 2 0.0008 0.00040

ACCE 2 10.3321 5.16604 1499.21 0.0000

DRM 2 0.7013 0.35063 101.76 0.0000

ACCE*DRM 4 4.1640 1.04099 302.10 0.0000

ERROR 16 0.055 0.00345

TOTAL 26 15.2533

GRAND MEAN 1.7656 CV 3.32

APPENDIX 14: ANALYSIS OF VARIANCE TABLE FOR ZINC.

Conclusion

The study was carried out to determine the effect of three different drying methods on the phytochemical properties of Ethiopian pepper. The quality attributes were proximate composition, mineral composition, anti-nutritional content as well as the qualitative and quantitative test of the fruits.

Oven drying was more efficient than solar and sun in reducing the moisture, increasing fat, ash and carbohydrate. Solar drying resulted in higher protein content while higher fibre content was given by sun dried fruits.

Solar dried fruits had higher calcium, iron, copper, and zinc while oven drying resulted in higher potassium and phosphorus content.

However, out of the five anti nutritional factors tested for, it was noted that all were greatly reduced by both oven and sun drying methods with phlobatannin appearing to be most affected. Also, shorter drying period has help maintain some on the chemicals that impart the spiciness into the fruits. The minimal destruction of the essential element of the Ethiopian pepper fruits and the retention of minerals and antioxidants as a result of the use of oven drying methods make it the best and proper way for processing the Ethiopian pepper.

Acknowledgements

I am highly indebted to the most High God for His faithfulness towards me. I hereby say a big THANK YOU to the almighty Allah. My heartfelt appreciation goes to my Supervisor, Mr. Patrick Kumah for his supervisory role, advice and support throughout the study period to this time.

I am also grateful to the head of the Department of Horticulture, Dr. Luara Atuah and the entire lecturers of the Department of Horticulture. Other thanks also go to Kwamina Bathels Addisou, Emmauel Nunoo Lartey and Ibrahim Yaala for their time and energy invested during the field and statistical data analysis.

Last but not least, I am grateful to Mr. Francis Amankwah, Bright Oteng Adarkwah and Mr. George Nortey at the Department of Soil science, KNUST; not forgetting Abanga Pual and Abanga Alhassan my course mates.

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