Original Research Article

EFFECT OF THREE DRYING METHODS (OVEN, SOLAR AND SUN) ON THE MINERAL COMPOSITION OF ETHIOPIAN PEPPER (*Xylopia aethiopica*)

The effect of oven, solar and sun drying methods on the mineral properties of the Ethiopian pepper was determined by conducting a study at the Department of Horticulture, KNUST using a Completely Randomized Design (CRD). The mineral properties analyzed were, calcium, iron, magnesium, sodium, zinc. Sun dried Ethiopian pepper, had significantly higher ($p \leq 0.01$) calcium (0.01%), iron (46.20mg/kg), magnesium (0.20%), sodium (0.9%), zinc (19.75mg/kg). Ethiopian Pepper dried under oven and solar drying methods retained the best minerals.

Comment [U1]: That's not what I see in table 4.2.

Comment [U2]: Idem

Comment [U3]: Oven was best for Zn content.

Keywords: Crucible, Distilled Water, Absorption Spectrophotometer, Replicates

1. INTRODUCTION

Ethiopian pepper *(Xylopia aethiopica* Insert authority*)* is of the Annonaceae family. The fresh and dried fruits, leaf, stem bark and root bark contain essential oils which help fight several bacteria and certain fungi ([7]; [8]).

X. 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 (insert citation). The plant is widely distributed in the West African rainforest from Senegal to Sudan in Eastern Africa, and down to Angolain Southern Africa ([3]; [2]) where it is mostly used for local cooking, especially in the preparation of what is referred to as ‘the African pepper soup [2].The bark when steeped in palm wine, is used to treat asthma, stomach-aches and rheumatism (insert citation).

The nutritional and chemical properties of fruit are affected as a result of the changes occurring during drying. Prolonged drying may result in some changes that could negatively affect some functional properties of the product (insert citation). 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 chemical characteristics in the fruit.

This research brings to light the appropriate drying methods which would still maintain the chemical content of the fruits. The effect of the drying methods on the chemicals of Ethiopian pepper has not been sufficiently investigated. It is therefore necessary to identify appropriate, easy and cost - effective drying methods that will maintain the fruit chemical properties. The research, therefore, sought to determine the effect of three drying methods (oven, sun and solar) on the chemical of Ethiopian pepper.

Comment [U4]: Conclusions must be linked to this phrase.

2. MATERIAL AND METHODS

2.1 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.

2.2 SOURCE OF ETHIOPIAN PEPPER

The Ethiopian pepper fruits were obtained from an out-grower farm located at Atobiase in the Bosomtwe District of the Ashanti region. Physiologically matured fruits were harvested and 300g of the fruit sample were weighed. The fruits were then graded and sorted to ensure they were of uniform size, shape and without damages. The fruits were then grouped into 3 sub-samples to be dried using the three drying methods (sun, oven and solar driers). Dried fruits were then processed into fine powder by grinding after which the samples were analyzed.

Plate 1: Freshly harvested Ethiopian pepper

2.3 DRYING TREATMENTS

2.3.1 SUN DRYING

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.

Comment [U5]: Ethiopian pepper or *Xylopia*? Use only one of the terms along the manuscript.

Plate 2: Sun dried *Xylopia* fruits

2.3.2 SOLAR DRYING

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.

Plate 3: Solar dried *Xylopia* fruits

2.3.3 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 $60^{\circ}C$ within 24 hours.

Plate 4: oven dried Xylopia fruits.

2.4 PARAMETERS STUDIED.

3.7 MINERAL DETERMINATION

A 1.0g of powdered *Xylopia* was weighed into a porcelain crucible and ashed for 4 hours at 500^{o}C. 10ml of 1:5 HCl to water was added to the ashed sample, digested on a hot plate and boiled for 2 mins. The digest was then filtered into a 100 ml flask, (raising the crucible well). The filtrate was made to the 100 ml meniscus mark of the volumetric flask using distilled water (insert reference).

The solution was further diluted with distilled water at a ratio of 1:50 using a combined solution of 2.5 ml lanthanum solution and 2.5 ml cesium oxide to remove the interference of other cations. The potassium, magnesium, manganese, zinc, sodium, iron, calcium and copper were read with the Absorption Spectrophotometer (AAS) using the respective wavelength after calibration. The specific elements were then calculated as

Calculation

Dilution Factor 50

(Ca, Mg, Na, K) % = Concentration x df

(Ca, Mg, Na, K) % = Concentration x 50/100 = concentration /2

The (Fe, Mn, Cu, Zn) ppm = concentration x coefficient factor

2.7 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 Turkey's Honesty significant difference (HSD) at 1%. The results were then presented in table.

Comment [U6]: The results were expressed as percentage or ppm? This is not clear along the manuscript.

3. RESULTS

4.2 EFFECT OF THREE DRYING METHODS ON THE MINERAL CONTENTS OF THE *XYLOPIA*

Table 4.2 presented the effect of three drying methods on the mineral contents of the Xylopia. The effect of the drying methods on the mineral contents varies among the *Xylopia*. K, Ca, Mg, Mn, Fe, Cu, were found in the dried *Xylopia*. Solar drying was found with highest content of Cu, Ca and Fe regardless of the drying method used. Also, there was significantly ($P<0.01$) difference between Ca, Cu and Fe in-terms of the three drying methods used. However, no significant ($P>0.01$) difference exist in Mg and K content examined regardless of the drying method used. Solar drying was found to recorded highest Cu content (90) among the drying methods used.

Comment [U7]: Rewrite.

Comment [U8]: What do you mean? Independent of the drying method?

Comment [U9]: In which unit of measurement

For the drying methods, the sodium content did not observe any significant difference ($p \geq 0.01$). However, the highest (1.50%) was recorded by oven drying and the least (0.98%) was recorded by sun drying. From the table, no significant difference ($p \geq 0.01$) was observed in the phosphorus content for the dried *Xylopia* subjected to the different drying methods. Sun dried *Xylopia* had the least (0.24%). Phosphorus content for solar dried *Xylopia* and oven dried *Xylopia* was the highest (0.28%).

The zinc content recorded a significant difference ($p \leq 0.01$) within the ranges 19.75mg/kg to 41.75mg/kg for the drying methods. Across the means of the drying methods, *Xylopia* fruits dried by oven had the highest zinc content (41.75mg/kg) followed by solar dried Xylopia

(28.25mg/kg) and the least (19.75mg/) was sun dried. The manganese showed significant differences (p ≤ 0.01) in the content from 312mg/kg to 300mg/kg.

Solar drying method had the highest (300mg/kg) content with oven and sun drying methods recording the least (312mg/kg) respectfully as shown in Table.

TABLE 4.2: EFFECTS OFTHREE DRYING METHODS ON THE MINERAL COMPOSITION OF *XYLOPIA AETHIOPICA*

Drying methods	Calcium	Copper	Iron	Potassium	Magnesium
OVEN	0.16 b	60.00 c	38.00 c	0.23 a	0.25 a
SOLAR	0.38 a	90.00 a	68.00 a	0.23 a	0.11 a
SUN	0.01 b	72.50 b	46.20 b	0.20 a	0.13 a
CV (%)	0.3	0.67	0.99	2.2	0.11
LSD (0.01)	0.22	1.51	1.51	0.15	0.15

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

TABLE 4.3 EFFECTS OF THREE DRYING METHODS ON THE MINERAL COMPOSITION OF *XYLOPIA AETHIOPICA*

Drying methods	Manganese	Nitrogen	Sodium	Phosphorus	Zinc
OVEN	3.12 a	2.54 b	1.50 a	0.28 a	41.75 a
SOLAR	3.00 b	2.80 ab	1.11 a	0.28 a	28.25 b
SUN	3.120 a	2.91 a	0.98 a	0.24 a	19.75 c
CV (%)	0.17	3.4	0.38	7.5	1.67
LSD (0.01)	1.51	0.28	1.51	0.06	1.51

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)

5. DISCUSION AND CONCLUSION

Comment [U10]: Insert conclusions in the end of this section.

5.2 EFFECTS OFTHREE DRYING METHODS ON MINERAL COMPOSITION

5.2.1 Iron

The Recommended Daily Allowance (RDA) of iron for infants, children and adults ranged from 6 - 15mg/kg while that obtained from the study, was from 3.8mg/kg -4.6mg/kg, slightly lower than that of the RDA. Iron helps in the growth and development of connective tissues and hormones. Its consumption is also vital for the production of hemoglobin and the oxygenation of red blood cells.

Comment [U11]: Do you mean mg/day? Aren´t you comparing different things?

5.2.2 Calcium

Calcium as an essential mineral helps in bone and teeth formation, as well as the proper growth of the body. Adanlawo and Ajibade, [1] reported a calcium content of 1.27% for the *Xylopia* fruits but from the study, the calcium content was comparatively lower (0.20% to 0.23%). This might be due prolong drying.

5.2.3 Potassium

Increasing potassium in the diet protects against hypertension for people who are sensitive to high levels of sodium [6]. Adanlawo and Ajibade, [1] as well as USDA, [12] reported 4.94% and 4% as the potassium content of the dried fruits.

Comment [U12]: In which species? Is it in general?

From the study, lower potassium content within the range of 0.20% - 0.23% was obtained. Potassium maintains the body's fluid volume and also promotes proper functioning of the nervous system [9].

5.2.4 Magnesium

Magnesium (Mg) is an activator of many enzyme systems which maintains electrical potential during nerve metabolism and Protein synthesis. It also helps in the assimilation of potassium ([11]; [10]).

The magnesium content found in Ethiopian pepper fruits was reported by Adanlawo and Ajibade [1] as 3.87%. Comparatively, the magnesium content (0.11% - 0.25) obtained from the studies was lower probably due to prolong drying.

5.2.5 Sodium

Sodium is a micronutrient that maintains osmotic pressure and helps in the relaxation of muscles [6]. The Sodium content according to USDA, [12] was reported as 0.0006 %. Comparatively, high sodium content (0.98% - 1.50%) obtained from the studies, might be due to differences in the drying methods used. Sodium helps in cell functioning as well as regulation of the body’s fluid volume.

5.2.6 Phosphorus

Phosphorus plays a vital role in metabolic processes and helps in the production of ATP. *Xylopia* fruits is reported to contain phosphorus of 0.004% [1]. From the study, a higher phosphorus content (0.24% - 0.28%) obtained might be due to differences in the drying method used. Consumption of phosphorus helps maintain balance with calcium for strong bones and teeth.

5.2.7 Zinc

Zinc helps in the breakdown of carbohydrates as well as maintaining the structural integrity of proteins [4]. The RDA for zinc is 15mg/kg [5] from the study, the zinc content obtained ranged from 0.82mg/kg - 3.06mg/kg which was comparatively lower than that reported by Adanlawo and Ajibade, [1]. Infants, children, adolescents and pregnant women would be at risk if the RDA for zinc is not met. To meet the RDA for the fruits, more of it needs to be consumed. Solar dried fruits had higher calcium, iron, copper, and zinc while oven drying resulted in higher potassium and phosphorus content.

REFERENCES

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APPENDIX

APPENDIX 1: ANALYSIS OF VARIANCE TABLE FOR ASH

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 2: ANALYSIS OF VARIANCE TABLE FOR CARBOHYDRATE

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 3: ANALYSIS OF VARIANCE TABLE FOR FAT

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 4: ANALYSIS OF VARIANCE TABLE FOR CRUDE FIBRE

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 5: ANALYSIS OF VARIANCE TABLE FOR MOISTURE CONTENT

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 6: ANALYSIS OF VARIANCE TABLE FOR PROTEIN

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 7: ANALYSIS OF VARIANCE TABLE FOR PH

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 8: ANALYSIS OF VARIANCE TABLE FOR CALCIUM

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 9: ANALYSIS OF VARIANCE TABLE FOR IRON

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 10: ANALYSIS OF VARIANCE TABLE FOR POTASSIUM

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 11: ANALYSIS OF VARIANCE TABLE FOR MAGNESIUM

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 12: ANALYSIS OF VARIANCE TABLE FOR SODIUM

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 13 ANALYSIS OF VARIANCE TABLE FOR PHOSPHORUS

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 14: ANALYSIS OF VARIANCE TABLE FOR ZINC

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