ASSESSMENT OF NUTRITIONAL CHANGES IN LOCALLY DRIED VEGETABLES

BY

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DEDICATION

This work is dedicated to the two men, Ayazau and Rhema
who show me Love daily and make me know
the joy of being a woman.

ACKNOWLEDGEMENT

Who can of himself do a thing when the Lord has not commanded it? Thanks be to the Lord God for divine enablement to do this work.

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Silver and Gold I have not, but all those who have been a blessing to me in several ways shall remain blessed.

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ABSTRACT

Vegetables were analysed for ascorbic acid, provitamin A (β-carotene), calcium potassium and sugar. Three vegetables, Tomato, Sweet pepper, and Okra were selected and both fresh and locally sun-dried samples were analysed. The nutritional values of the locally sun-dried vegetables were compared to those of the fresh and the changes evaluated.

Carotene retention in locally sundried vegetables was quite lower in all vegetables than the fresh, with tomato recording the highest percent loss. The traditional method of sun drying which does not involve blanching and sulphiting causes ascorbic acid difference in all analysed vegetables ranging from 72.5 mg in sweet pepper to 15.8mg/100g in okra with tomato recording the highest difference of 73.5%

Calcium and potassium changes were not appreciable while sugar concentration in sun - dried vegetables were higher.

Adult intake of carotene and ascorbic acid from dried tomato, pepper and okra sold in the market which are used in most Nigerian diet at non production seasons will be inadequate after cooking compared with recommended daily allowance.

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INTRODUCTION

Food is a basic necessity for life. It provides certain chemical substances called nutrients. Nutrients perform the following functions. (i) They build, repair or maintain body tissue. (ii) They help regulate body processes. (iii) They provide energy to maintain all body functions. These nutrients are classified into carbohydrates, proteins, fats, vitamins and minerals.

Most Nigerian diets are rich in carbohydrates and fat which are energy sources and protein for growth and maintenance of body tissues. These nutrients are sourced from food such as cereals, root and tubers, legumes, oils nuts and pulses, these foods are poor in vitamin ands minerals. (Table 1.1).

Nutritional survey and studies show that there is occurrence of nutritional deficiencies which appear to differ with geographical location, income group and socio-economic activities. Studies have also shown the low level of micronutrients (vitamins and mineral) deficiencies such as vitamin A and C, calcium, iodine and iron in several parts of Nigeria. Igene (1996). Also per capita food production and intake have steadily declined over the last decade, one reason among others being poor food processing, preservation and storage, World bank (1991).

Vitamins and minerals are essential for proper body growth and good health. This class of nutrient are usually available naturally in fruits and vegetables. In the absence of adequate animal protein intake due to high household food insecurity Sharma (1992)FAO (1992), vegetable and fruits are the cheapest and most available sources of these micronutrients.

1.1 VEGETABLES

Vegetables from culinary and nutritional point of view are classified as plant or part of plants as follows:

1. Leafy vegetables: cabbage, lettuce, Amaranthus etc

TABLE 1.1 NUTRITIONAL VALUE OF SOME NIGERIAN STAPLE FOOD MEASURED PER 100g EDIBLE PORTION : SOURCE: TINDAL ,1983)

						Minerals (Mg)				Vitamins (Mg)						
		Water %	Caloros K/Cal	Prokin g	C/Hidrate (iotal)	Calcium	Iron	Phospho-rus	Pottas-sium	Vit A (µg)	Thia-mina	Ribof-lavin	Nia-cin	Folic Acid	Vit C	Fat
1.	White Maize(dried)	12	345	94	72	16	1.8	220	250	0.00	0.33	0.10	2.2	-	0	4.2
2.	Millet (Jero)	11	315	7.4	73	395	17	245	260	25	0.18	0.11	0.8	-	3.0	1.3
3.	Sorghum	10	345	11.0	72	26.0	11	330	200	20	0.34	0.15	3.3	-	0	3.2
4.	Rice(Slightly milled and perboiled)	12	335	7.0	80	9.0	1.7	125	110	00	0.34	0.03	2.6	29	0	0.5
5.	Cassava (meal)	3	320	1.6	82	66.0	3.6	135	885	0	0.66	0.05	0.6	24	31	0.5
6.	Plantain(Raw & Ripe)	6.5	120	1.2	3.9	8.0	1.3	38	385	390	0.08	0.04	0.6	16	20	0.3
7.	Potato(Pale-Sweet)	69	110	1.6	28	33	2.0	38	20	35	0.09	0.04	0.7	52	37	0.2
8.	Potato(Yellow Sweet)	69	110	1.6	28	33	2.0	38	20	1800	0.09	0.04	0.7	52	37	0.2
9.	Yam Fresh	69	110	1.9	27	52	0.8	61	295	15	0.11	0.02	0.3	-	6	0.2
10.	Yam Flour(Elubo)	14	310	3.4	78	20	1.1	110	-	0	0.1	0.08	1.1	-	0	0.4
11.	Cowpea(White & black)	11	320	23	57	80	5.0	400	800	15	0.9	0.15	2.0	349	2	1.4
12.	Soya bean	11	405	34	29	185	6.1	540	1700	28	0.71	014	2.9	100	0	18
13.	Ground Nuts	7	570	23	20	49	3.8	410	680	13	0.03	0.03	0.6	14	8	45
14.	Mellon	6	595	26	11	53	7.4	760	-	-	110	112	1.4	-	-	50
15.	Amorranthus (Raw)	84	45	46	70	562	84	100	575	230	0.05	0.42	1.20	2.0	30	0.2
16.	Baobab(Kuka)	77	39	4.0	7	400	1.1	65	-	-	-	-	-	-	52	-
17.	Carrot	89	35	0.9	8.0	35	0.7	38	250	6000	0.04	0.04	0.6	8.0	8.0	0.1
18.	Cucumber(Raw)	95	14	0.8	3	13	0.5	30	140	-	0.02	0.01	0.3	6	14	0.1
19.	Lettuce	94	80	1.2	4.0	26.0	0.7	40	230	1950	0.06	0.15	0.4	89	10	0.2
20.	Okra Pod	89	35	2.1	7.0	84	1.7	90	290	190	0.04	0.08	0.6	23	47	0.2
21.	Onion (Bub)	88	38	1.2	9.0	27	0.8	45	170	-	0.02	0.04	0.2	0.14	11	0.1
22.	Pepper(Red Sweet)	86	44	2.0	8.0	29	2.6	61	440	640	0.12	0.15	0.15	2.2	24	0.8
23.	Tomato Raw	94	22	1.0	4.0	10	0.6	24	300	380	0.06	0.04	0.6	28	26	0.2
24.	Banana(Ripe)	77	82	1.5	9.0	9.0	1.4	1.2	400	90	0.03	0.03	0.6	19	9	0.1
25.	Guava	82	46.0	1.1	10	24	1.3	31	290	220	0.06	0.04	1.3	7	325	0.4
26.	Mango(Ripe & Wilhart skin)	83	60	0.6	15	24	1.2	22	215	2400	0.03	0.05	0.4	7	42	0.2
27.	Pawpaw	91	30	0.4	7	21	0.6	15	220	300	0.03	0.03	0.4	1	52	0.1
28.	Pineapple	87	48	0.4	12	16	0.4	140	200	[illegible]	0.06	0.03	0.1	11	34	0.1
29.	Eggs	75	140	12	0	45	2	200	150	[illegible]	1	0.3	0.3	25	-	-
30.	Palm Oil (Fresh)	1	850	0	1	6.0	0	7	[illegible]	[illegible]	[illegible]	0.02	-	-	-	99

2. Roots and tuber and bulbs: carrots, potato, onions

3. Flowers vegetables: Cauliflower, broccoli etc

4. Fruity vegetables: Tomato, pepper, aubergines, cucumber Okra etc

Nutritional data show that vegetables are rich sources of vitamins A, C and B - groups. They also contain protein (in seeds), low to average carbohydrate and minerals as such calcium phosphorus, iron, potassium and iodine.

Vegetables are grown all over Nigeria but types differ with climatic conditions. In the Northern part of Nigeria chiefly grown vegetables are Carrot, Cabbage, Tomatoes, Okra, Pepper, Potatoes, Spinach, Cucumber etc. Tomatoes, Pepper and Okra have been selected for this work, because they are daily eaten by all classes in sauces and soups.

1.2 TOMATO, PEPPER AND OKRA

These vegetables are common in an average Nigerian's diet and eaten in various forms and often. In spite of this, considering the nutritional values of food (Table 1.1), reports have stated vitamins and mineral deficiencies, notably vitamins A, C, folic acid, B - group, calcium and iron in many part of the country, (Igene, 1996).

The production and distribution of these vegetables is predominant between the raining and harmattan period, most of which are wasted due to inadequate preservation methods. However, farmers try to ensure availability of these crops during off-production periods sequel to demand by drying them.

Drying is a major way of preserving vegetable in developing countries including Nigeria, contrary to canning and freezing in developed countries. Dried Tomato, pepper (all species) and okra are commonly displayed in Nigerian markets

particularly in off-production seasons. They are usually visibly mouldy and highly decolourised as a result of dehydration and storage. Since these vegetables are valuable micronutrient sources, it is important that drying technique ensure maximum nutrient retention in dried products. While sun-drying is being increasingly adapted in vegetable preservation due to the high cost and skill required of other artificial drying methods, conservation of nutrient is very important in view of the prevalent micronutrient deficiency problems.

Mineral content of vegetables are stable to dehydration, the vitamins are highly labile and are destroyed through enzymes, oxidation and photo degradation mechanisms. Therefore, the nutritional changes that occur in some selected locally sun dried vegetables is being studied.

1.3 OBJECTIVES

The major objectives of this project work are:

1. To determine the values of major vitamins and minerals as well as sugar content of fresh tomato, okra and pepper.
2. To determine the values of major vitamins, minerals and sugar content of sun - dried tomato, Okra and pepper, sold in the market.
3. To assess the changes in the dried vegetables, thus effect of sun drying on the nutrient quality of these vegetables.

1.4 JUSTIFICATION

Vegetables which are relatively rich and cheap sources of micro-nutrients are produced (80 - 90%) majorly by peasant farmers in Nigeria, (Onayemi, 1981). Sundrying is the peasants' affordable and major method of preserving these high moisture produce to

prevent shortage during off-production periods. Literatures have shown that sundrying has a depletive effect on nutrient of vegetables, especially vitamins. If the daily dietary requirement of these nutrients is to be met all year round, then the extent of their availability in sun - dried products must be assessed.

Common to all parts and culture in Nigeria and primary in most meals among various vegetables grown are tomato, okra, pepper and onion. Onion is cured while others are preserved by sun drying and consumed in dried form.

Very little information is available on vitamins, minerals and sugar composition of these dried vegetables with particular reference to Nigeria.

This research work is to assess the changes in nutritional values in sun dried vegetables sold in Nigerian market hence the level of nutrients available in diet of Nigerians particularly low-income groups during off-seasons.

2.0 LITERATURE REVIEW

Vegetables are desirable component of any diet because they provide a complete range of nutrients required. Their production is seasonal. In Nigeria, periods of surplus are between August and March. April to July, there are shortages which can result in variety and nutritional content of the diet being restricted especially among the low-income group.

2.1 FOOD VALUES OF VEGETABLES.

Vegetables are not often accorded the importance in diet of many Nigerian households due to ignorance of the nutritive values of these food items. Generally, vegetables are: -

i. Rich in water content

ii. High in cellulose and low in calories except bulbs, roots and tuber vegetables, which are moderate in cellulose.

iii. Rich in provitamin A, ascorbic acid and some B - group vitamins.

iv. Most vegetables contain some amount of calcium, phosphorus, potassium and trace amount of iron.

v. Bulbs, roots and some fruity vegetables contain appreciable amount of carbohydrates such as glucose and fructose.

2.1.1 CARBOHYDRATES

Carbohydrates in vegetable exist as monosaccharides and majority as glucose and fructose. (Table 2.1) Cellulose which also contain many unit of glucose accounts for 50% of all carbon in vegetables, (Guthrie, 1979)

Table 2.1 Distribution of sugars in some selected food materials (g/100g food)

Food	Glucose	Fructose	Sucrose
Cabbage	1.6	1.2	0.2
Carrot	0.9	0.9	4.2
Onion	2.1	1.1	0.9
Potato	1.0	1.2	1.7
Tomato	1.1	1.3	0.0

SOURCE: Guthrie, (1979).

2.1.2 MINERALS

Minerals are essential inorganic elements derived from food and needed in the body. They are classified as macro elements (calcium, phosphorus, potassium etc) and micro - elements which include iron, iodine copper etc. Predominant minerals in vegetables are calcium, phosphorus and potassium, others are trace in quantity.

Calcium is important in bone and teeth formation and development (1.5 - 2% of body weight) and required for adequate cell function. Vegetables contribute about 10% of calcium while milk and milk products supply about 76% (Guthrie, 1979).

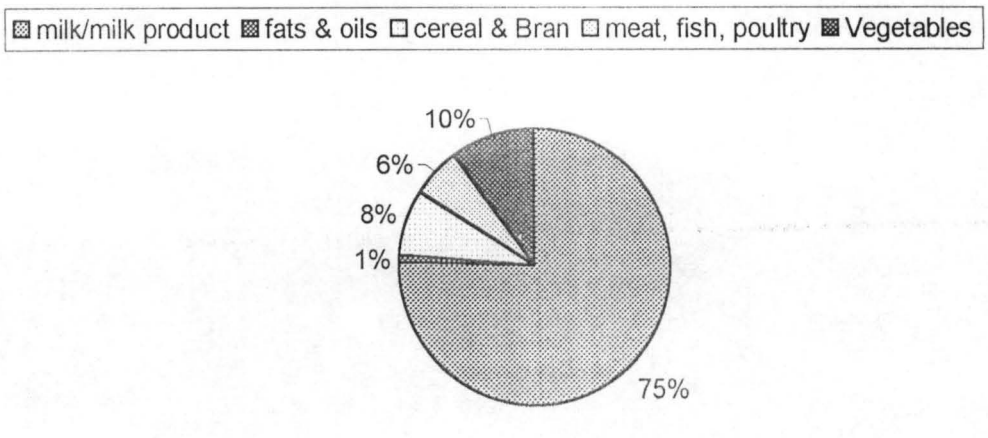

Fig 2.1 Contribution of Various Foods to the calcium content of Diets

SOURCE: National Food Review NFR - 1 WASHINTON DC. Economic Research Service 1978.

In developing nations as Nigeria where milk and milk products are rarely affordable among the low-income groups, frequent eating of vegetables is capable of meeting daily dietary requirement of calcium subject to amount available after cooking.

Vegetables when unprocessed are good sources of potassium (e.g. tomato and potato), (Brown sell 1989). Fresh fruits and vegetables are low in sodium, but its need is met by potassium.

2.1.3 VITAMINS

These are organic substances needed in small amount by the body, they perform specific metabolic function and are therefore important in human diet. Vitamins are grouped into fat-soluble (A, D, E & K) and water soluble vitamins (C, and B-group).

Vitamin intake is determined by the amount in a particular food and the amount of such food consumed. Vitamins are essentially from food items since it cannot be synthesis

by man adequatly for daily need. Plants have ability to do so hence primary source of this dietary essential.

FAT SOLUBLE VITAMINS

The most predominant of the group in vegetables is vitamin A.

Vitamin A (Retinol) is not available in plants but animal foods, however provitamin A and specifically β-carotene is converted into Retinol in the body. The vitamin A content of vegetables is thus measured by amount of carotene content.

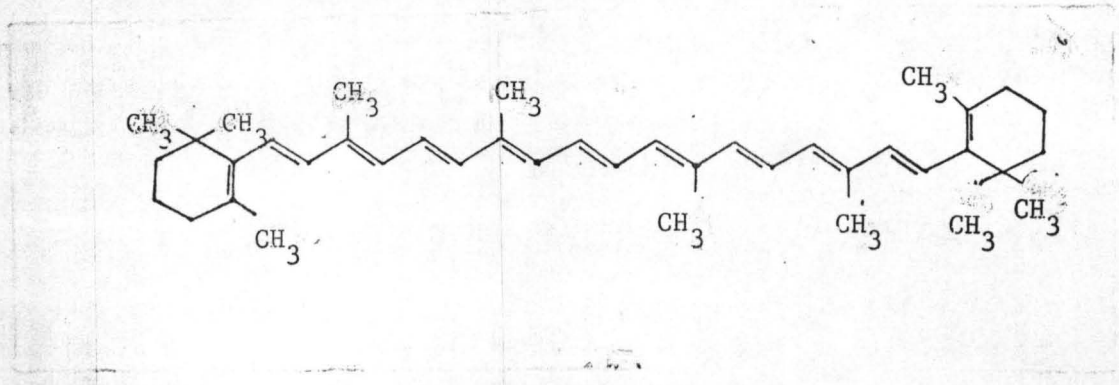

Fig. 2.2 Structure of β carotene.

Bail (1994), reports that 85 - 97% of provitamin A in vegetables are in form of β - carotene.

Table 2.2 : Distribution of Provitamin A in some fruits and vegetables

FOOD	**μ_g (Retinol Equivalent) per 100g**
Carrot	2000
Leafy green leaves	685
Tomato	100
Potato (Sweet, white)	50
Potato (Sweet, yellow)	670
Orange	80
Banana	30
Papaya	57
Mango	133

SOURCE: Ball, (1994.)

*Retinol equivalent = β carotene divided by 6

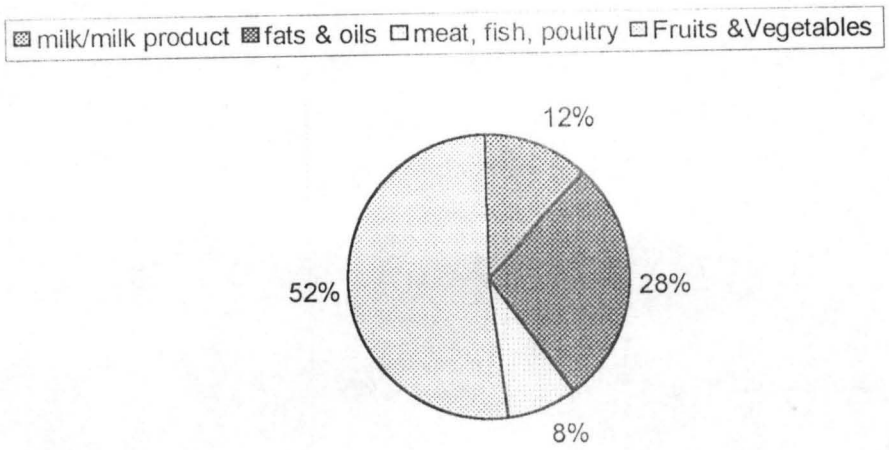

Fig. 2.3 Contribution of various food groups to vitamin A content of food supply.

(Adapted from introductory Nutrition by Helen Andrew Guthrie 4th edtion 1979.)

Retinol and β-carotene are soluble in oil but not in water. It is liable to oxidation when heated in the presence of oxygen, hence during drying of tropical products.

WATER SOLUBLE VITAMINS.

Vitamin C (ascorbic acid) is predominant among water soluble vitamins in vegetables and are either as L-ascorbic acid ($C_6H_8O_6$) and or hydroascorbic acid ($C_6H_6O_6$) Mathew and Hall (1978) reports that L-ascorbic acid forms 97% of total ascorbic acid in fresh green vegetables, and is concentrated during ripening process, (Oi-wah Lau et al, 1985).

Fruits are reported to have higher Vitamin C then vegetables. In northern parts of Nigeria where fruits are not ecologically viable, fresh green vegetables, tomato, onion, pepper and okra etc are primary sources of natural vitamin C (Olaosegba, (1976)

Studies have shown that ascorbic acid is destroyed due to normal enzymatic activity in storage. It is also easily destroyed by aerobic oxidation which is the most predominant factor of vitamin C loss.

2.2 *REVIEW OF SELECTED VEGETABLES*

2.2.1 TOMATO (Lycopersicum esculen tum)

Tomato is a vegetable grown for its edible fruit. It belongs to the Lycopersicum group, and tropically grown. It is one of the most important vegetables that have been cultivated for a long time in Nigeria. It is an important component of the daily diet of every Nigerian, consumed both fresh and in a paste form.

In Nigeria, tomato is mostly cultivated in northern and south western states with Zaria, Kaduna, Kano, Gombe, Sokoto, Maiduguri, Jos, Ilorin, Ibadan, Ogbomoso as major areas. The crop is planted during, both the wet season as rain fed crop in the north; June - July and March to April in the south - western area and in the dry season October - November with Irrigation in the North and November - March in the south. Peak period of harvest is from January to March, this period being longer in the south than North, while higher yield are obtain in the dry season in the north (Denton and Swarup 1988).

Nutritive Value

Tomato is estimated to have vitamin C between20 - 25 mg/100gm edible portion. Literatures show that vitamin A content range from 267 - 700µg carotene per 100g (i.e. 44.5- 117µg retinol per 100g and about 1000IU vitamin A. The seed is rich in protein, while most its soluble solid exist as fructose and glucose (NIHORT 1986). Tomatoes does not rank high in these nutrient concentration per se, It is reported to rank 13th in Vitamin C, 16th in Vitamin A Villareal (1980), reported that owing to its large consumption rate, tomato ranks 3rd as actual source of these vitamins.

2.2.2 SWEET PEPPER. (Capiscum annum.)

This specie of pepper is spread round the tropics. The fruit commonly called Tatase in Nigeria is bell shaped, and used as spices in most meals. It is grown predominately in the north like tomato, and transported to other parts of the country.

Nutritive values: Studies have shown that Sweet pepper contains about 250 - 640 μg Carotene (41.6-106μg Retinol) per 100g edible portion and Vitamin C of 100 - 149mg /100g edible portion. Oyebiodun et al (1982) reports that sun-dried Capiscum annum have average values of calcium and phosphorus as 74 and 103mg/100mg respectively.

2.2.3 OKRA (Hybiscus esculentum)

Okra is a coarse erect annual plant with an edible fruit in form of pods. Okra is grown in most areas of Nigeria and used for soups either as fresh or sundried. It is usually grown at the set of wet season between March and April in the south-western areas and April - July in the central and Northern areas. Harvest starts about June and August in the south - west and northern areas respectively, with peak period in August - September.

Nutritive Value

Ahigbe (1984), reported fresh Okra to contain Carotene of 80 - 114μg/100g of edible portion while traditionally dried ones have 5.65 - 6.85μg/100g. L - ascorbic acid is reported as 31 - 35 mg/100g. Addo, (1983), indicated a value of 47.2mg/100g ascorbic acid. King et-all (1992) reports a value of Retinol as 32 μg/100g edible portion of okra. (i.e 192 μg β-Carotene).

2.3 VEGETABLE PRESERVATION METHODS

The preservation of vegetables involve checking enzymic actions and destroying or retarding the growth of micro-organisms and undesirable chemical alteration. These can be achieved by canning, freezing, fermentation, freeze-drying .air drying etc. Brief reviews of these processes are given below.

2.3.1 Effect of Preservation Methods on Nutritive Values of vegetables.

Anne - Presslay et.al (1994) carried out on analysis of vitamins A and C content of some canned vegetable. Vitamin A was highly retained except in tomato, asparagus and peas. Vitamin C values were within 16.5 - 11.4mg/100g. Guerrant et al (1946), reported the effect of canning on the vitamin A content of fruits and vegetables and reports that carotene content were highly retained while ascorbic acid loss was proportional to the amount of air trapped in the can.

Gaudeloupe (1996), reported in a work on conservation of vegetables by lactic fermentation, Okra has been treated this way with vitamins and other nutrients retained. Humbert and Luzmaria (1983), analysed ascorbic acid, total sugar, total acidity and pH lactic acid fermented tomatoes. Ascorbic acid value was 5mg/100g. Though technically feasible, the ascorbic acid diminution is a limitation to this method.

Compared with other methods of preservation, the quality of frozen vegetables is said to be inferior to only fresh ones. Successful freezing of vegetable involves inactivation of enzymes by blanching. Buret et al (1983), reports that there is a high loss of vitamin C when frozen tomato is being thawed.

Vegetables being high moisture foods are perishable and thus preserved in most developing nations by sun - drying. Literature has shown that vitamins are lost during dehydration. Mottran (1991), points out that slow drying in air provides best environment for ascorbic acid destruction. If enzymes can be rapidly destroyed and drying is with little exposure to air, 60 - 80% of ascorbic acid can be preserved. Fisher (1985) reports that when pepper is locally dried in open air, they lose a large amount of vitamins but when rapidly dried at low temp, using modern drying method much less is lost. Benden(1991), reports an overall loss in vitamin A resultant from different dehydration methods of dehydrating carrot. This is shown in the table 2.3 below.

Table 2.3: Concentration of Provitamin A in dehydrated carrot.

SAMPLE	**(CONCENTRATION) mg/100g**
Fresh	98 - 186
Explosive Puff dried	81 - 101
Vacuum freeze dried	87 - 113
Conventional sun-air dried	64 - 99

Davidek et - al (1991), showed also from the chart that vitamin C is least retained in sun-air drying of peas.

Traditionally in Nigeria, sun drying is a major vegetable preservation method.

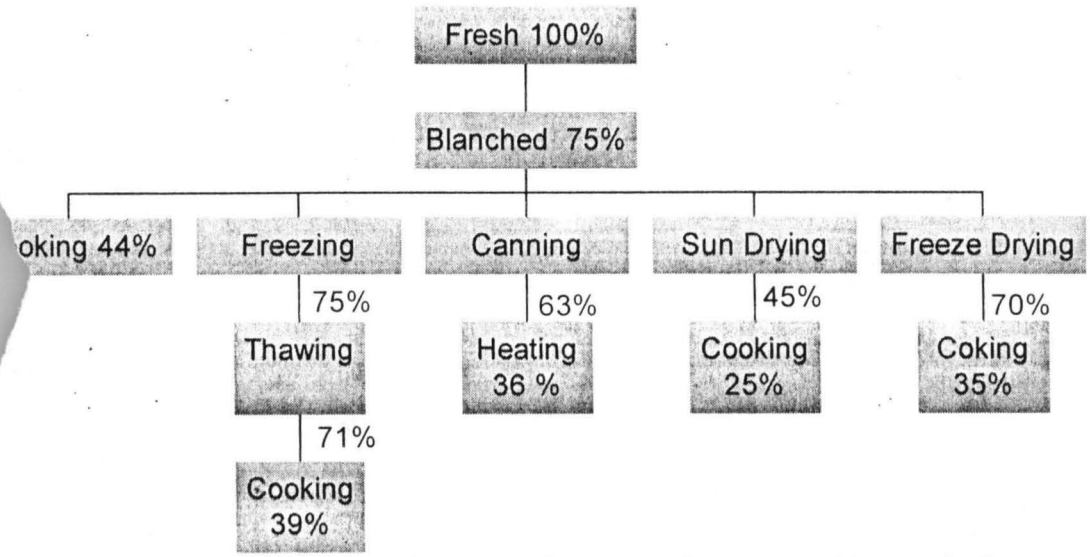

Fig. 2.4: Effect of processing methods of retention of ascorbic acid in Peas

Source: Davidek, et al (1991)

2.3.2 PRE-DRYING OPERATIONS

Two pre-drying operation reported to have major effects on quality and nutritive value of dried vegetables are blanching and sulphiding.

Blanching has been reported to improve keeping qualities and preserve natural colour. It can be done either by water or steam. Etchetema (1991) blanched Okra prior to drying, result showed 72% initial colour retention.

Oyebiodun et-al(1982) reported traditional pre-cooking (blanching) of pepper, this facilitate quick sun drying. Ahigbe (1984), in analysis of dried okra showed that vitamin C retention rate are higher in steam than water blanched samples. Nutting et-al (1970), reported that unblanched parsley retained more β-carotene than blanched ones after drying.

SULPHITING

Ahigbe (1984) compared sulphited and unsulphited sun-dried okra, and reported no oxidative browning effect in sulphited samples. Sulphiting reduces ascorbic acid loss during further processing and in store. This is because So_2 reduces hydrogen peroxide which is formed by oxidation of ascorbic acid, indirectly protecting ascorbic acid.

Sun-dried vegetables sold in the market are not blanched nor sulphited. Report from verbal interview with some local farmers showed that tomato and okra are simply sliced and spread in the open air on the farm drying floors or roof tops.

2.4 QUALITY CHANGES IN DRIED VEGETABLES.

In Nigeria, some works have been done on analysis of proximate composition and a few work on vitamin analysis in

fresh vegetables. Very little attention has however been given to analysis of carotene, ascorbic acid, sugar and mineral contents of processed vegetables especially dried ones.

Bolin and Strafford (1974) studied the effects of drying on provitamin A (carotene and vitamin C in apricot, using sundried, shade dried and drum dried samples, with or without sulphiting.

The result showed that sulphited and sundried samples has 10% loss less than other sample while unsulphited sun dried samples had 30% loss of β-carotene. Gomez (1981), reported that ambient temperature - open drying resulted in lowest carotene retention compared to other methods.

2.5. EFFECT OF DRYING ON NUTRITIVE VALUES OF SELECTED VEGETABLES

2.5.1 OKRA. (Hibiscus esculentum)

Ahigbe (1984), reported that sun-drying while aiding preservation was found to account for 80% loss in β-carotene and vitamin C .

Addo (1983) showed a considerable loss of 44.7% in vitamin C content of okra due to sun drying. Soups made from dried okra contained 5.37mg/100g compared to 18.58 mg/100g in fresh okra soup. FAO (1968), shows that cooking also lower the mineral content of okra.

2.5.2 SWEET PEPPER. (*Capiscum anuum*).

Oyebiodun et-all (1982) reported proximate composition of different varieties of pepper as well as calcium, phosphorus and iron in both traditional sun dried and fresh pepper. Sweet pepper recorded a decrease in calcium from 67.1 to 14.4 after drying. This was attributed to pre-drying operations as FAO (1968), reports that analysis of pepper, dried and fresh, indicate no calcium loss during drying. Koll et-al (1987), reports that high drying temperature and long drying time (characterised by sun drying) deteriorates quality. Coleman et-al (1979), found that changes in colour and flavour of sun-dried sweet pepper are not as great as changes in vitamin C content.

Nwachukwu (1988) compared nutrient content of sundried peppers under different storage conditions. Samples of grounded and whole sun dried pepper under all conditions recorded highest losses.

Addo (1983), reported 48.5% loss in ascorbic acid of sun dried Capiscum annum a value of 153.1 - 64.3 mg/100g.

2.5.3 TOMATO (*LYCOPERSICUM ESCULENTUM*)

NIHORT (1986), reported that retention of natural red colour (canotenoid) is an important problem in dried tomato as prolong heating at high temperature is harmful to lycopene. The extent of destruction was not analysed.

Addo (1983), did not report specific level of loss in dried vegetables, however, stew made from sun dried tomato was reported to have 0.91 ± 0.02 mg/100g ascorbic acid. Very little research has been done specially on dried tomato both in Nigeria and in developed countries, since in develop countries, tomato is rather canned or frozen than dried.

2.6 *NUTRIENTS ANALYSIS*

Analytical techniques that have been routinely applied in quantitative analysis of vitamins, minerals and sugar in food vary with types of food and nutrient, accuracy and limitations.

2.6.1 VITAMIN C.

The analytical methods involved in vitamin C. determination includes:

1. Titrimetric method using 2,- 6 dichlorophenol indophenol dye (DCPIP).
2. Voltametric method (including polarography)
3. Colorimetric method using of 2, - 4 dinitro-pheny/hydrazine (DNPH).
4. Fluorimetric method using UV. Irradiation
5. Spectrophotometric method using U.V. visible absorption spectroscopy.
6. High performance liquid chromatography (HPLC) method.

These AOAC(Association Of Analytical Chemist) methods have the following advantages and limitations in their use for food materials and particularly vegetables.

Titrimetic method can be used for determination of only L-ascorbic acid (which is predominant in vegetables and not total vitamin C, but difficult with coloured extracts. Where vegetables have been sulphited, an interference by reductions occur, giving inaccurate results. It is however simple and rapid.

The A.O.A.C. Microfluorimetric method provides a value for total vitamin C activity and less susceptible to reductions, this is however lengthy and tedious, compared

with DCPIP and colorimetric method but more suitable in foods (Deutsch and Wills (1965) Colorimetric method using 2, - 4, dinitro-pheny/hydrazine is adaptable where vitamic C is as hydroascorbic acid.

The High performance liquid chromatagraphic method is highly accurate for L-ascorbic determination but very expensive.

2.6.2 VITAMIN A.

A.O.A.C. methods involved in analysis of vitamin A (retinol) and provitamin A (carotene) includes:

(i) Spectrophotometic method

(ii) Colorimetric method. This is specifically adapted to retinol determination

(iii) Column chromatography method: This is adapted to determination of β- carotene (Pro vitamin A) and has a wide range where spectro-phtometric method is not adaptable (Ball, 1994). Nutting et al (1970), used the column chromatographic method in determining β carotene in some vegetables, with satisfactory results.

2.6.3 MINERALS

Mineral analysis in food involves the following methods

i. Gravimatric method for calcium

ii. Titrimetic method using ethylene diemine tetra acetic acid (EDTA) solution.

iii. Spectrophotometric method for calcuim and potassium

iv. flame photometric method, for calcium and potassium.

The flame photometric and spectrophotometric methods are employed in vegetable analysis due to the small amount (mg) of minerals present.

Nwokolo. (1984); Ron et al (1984), and Oyebiodum et al (1982), all employed the A.A. spectrophotometric method in determining calcium and potassium.

Reducing sugar analysis methods include:

i. Copper reduction methods (volumetric and gravimetric methods for glucose, sucrose.

ii. Polarimetry for sucrose

iii. Thin layer chromatography

iv. H P L C method

v. Colorimetric method

Polarimetric method is reported to be more accurate than copper reducing method while the other is cheaper; however these are more time consuming compared to colorimetric method.

Ron et al (1984, used the HPLC method for reducing sugars in vegetables while Blackeney et al (1980) used the simple colorimetric method. These results were comparatively close and quite adequate for vegetables in particular.

CHAPTER THREE

3.0 MATERIALS AND METHODS OF EXPERIMENT

The nutritional contents of dried and fresh selected vegetables were assessed by laboratory analysis using A.O.A.C. methods

3.1 MATERIALS FOR EXPERIMENT

Vegetables analysed are Tomato (Lycopersicum esculentum) - Ronita cultiva; Sweet pepper (Capiscum annum) and Okra (Hybiscus esculentum) 44-7 variety. All samples, fresh and dried were purchased from the local market in Minna. These were cleaned, destalked and grinded. Samples of each vegetable were digested and placed in air tight containers and held at 1° C while being analysed over a period of 2 - 3 days. Beakers (50, 100ml), pipettes (1, 5, & 10ml), test-tubes, filter papers, funnels,computerized weighing machines, and home grinders were used along with specified instruments and reagents for each experiment.

3.2 METHODS OF EXPERIMENT

3.2.1 Vitamin A (Provitamin) Analysis using spectrophotometric method

Reagents/Materials

Isopropanol

Vitamin A standard solution (1μg per ml or 1ppm) made from Vit. A tablets.

Samples of vegetables

Procedure

5.0 gm of vegetable sample was weighed into a beaker and 15mls of isopropanol was added. The mixture was left for 20 minutes to allow complete extraction, and then filtered through Watman No. 1 filter paper.

0.1ml of extract was pipetted into a beaker and 9.90ml of isopropanol was added to make it up to 10mls.

Vitamin A standard solution was prepared by weighing 1.0 mg of Avita Vit. A tablet and dissolved in 10mls of isopopernol. 0.1ml of solution was then diluted with 9.90 ml of isopropanol. 5ml blank solution of isopropanol was also pipetted into a beaker.

The spectrophotometer was set at 325nm and zero absorbance. The blank solution was used to standardise the spectrophotometer.

The Vitamin A standard solution was poured into a cuvette and the absorbance was read (S_1). The standard solution is then passed through an ultraviolet lamp until extinction becomes stable with time. This was done for 15min. The standard solution absorbance was read again (S_2).

Sample of each vegetable extract was powered into a cuvette and absorbance level read (T_1). These were equally passed through the ultraviolet lamp and after 15min, the level of absorbance was read (T_1) as shown in Appendix A_1.

The concentration of vitamin A was thus calculated by given expression.

$$\text{Vit A } (\mu g/mg) = \frac{T_1 - T_2 \text{ X Dilution factors}}{S_1 - S_2}$$

3.2.2 DETERMINATION OF VITAMIC C BY TITRIMETRIC METHOD USING 2,6 DICHLORO PHENOL INDOPHENOL.

Ascorbic acid was analysed by titration with 2,6 - Dichloro phonol indophenol (DCPIP) dye. The DCPIP dye is reduced by ascorbic acid to a colourless solution. Ascorbic acid is extracted from a food item and titrated against DCPIP.

REAGENTS

1. Meta phosphoric acid - acetic acid stabilising extracting solution. (15g meta phosphoric acid in 40ml glacial acetic and 450ml of distilled water.)

2. Ascorbic acid standard solution containing 50mg of ascorbic acid mixed with 100ml meta phosphoric glacial acetic to make up 1000ml.

3. Indo phenol standard solution. 10mg of DCPIP was dissolved in 100ml of distilled water.

PREPARATION OF SAMPLE AND DETERMINATION OF VITAMIN C.

The dye solution was standardised with standard ascorbic acid solution.

Approximately 15ml of metaphosglacial acetic mixture was poured into screwed top jars with tight fitting to prevent oxidation of ascorbic acid. 5gm of each sample class (dried and fresh) of vegetable was weighed and put into each jar and these were thoroughly mixed and grinded in a mortar.10ml of each mixed grounded sample were poured into boiling tube each and 1.0gm of activated charcoal was added. This was left for about 10 minutes to decolourise the sample. (This was done to only tomato and pepper samples) Upon decolourisation the content of the container was filtered through a Whatman No.1 filter paper into a 100ml conical flask. The extraction procedure was carried out using 10mls metaphosglacial acetic mixture and distilled water to a 100ml solution (Blank solution).

This was put in a flask. 5ml aliquot portion and blank solution were taken after filtering and titrated against the DCPIP dye, the amount of dye at a point where the sample colour became faint and then permanently pink was noted. With these values the amount of vitamin in the samples were determined as shown in the results table. (Appendix A2)

3.2.3. DETERMINATION OF CALCIUM AND POTASSIUM USING THE UNICAM 9100 A.A SPECTROPHOTOMETER.

Determinations of calcium and potassium using the Atomic Absorption spectra phometric were done on an extract made by ashing a sample of food and dissolving the ash in a suitable solvent. The samples are passed through the spectra photometer which absorbs the quantity of the mineral and burns it in a rich hot flame.

REAGENT

1. Releasing agent: 0.1% w/v lanthanum chloride.

2. Standard calcium stock solution.2.479g calcium carbornate dissolved into a slurry with 300mls of distilled and deionised water, into which 10mls of concentrated Hydrochloric acid was added.This solution contains 1000ppm Ca .

3. Standard calcium working solutions: A range of standard working solutions made from calcium stock using 20,40 60, 80 and 100ppm.

PROCEDURE

1.0gm each sample was ashed, moistened with water and carefully diluted with 10ml diluted hydrochloric acid. The mixture was evaporated to dryness and heated further for 1hr, then cooled. 10ml of water and 5ml normal hydrochloric acid were added and the mixtures boiled and filtered into a 100ml flask. These were made up to 100ml each by adding water after cooling. The atomic absorption spectro photometer was set with a 5 A cathode lamp to a line at 422.7nm and a rich air - acetylene flame.

To 9.0ml of each sample solution, 0.1% w/v lanthanum chloride was added to suppress the interaction effect of phosphorus. Using a blank solution, the A.A spectro photometer was cleaned by spraying with water then the standard working solutions were sprayed to standardise the instrument.

The sample solutions containing lanthanum were passed through the spectro photometer having selected a concentration reading instead of absorbance. With this selection the concentration of calcium per sample solution was read from the instrument, in three replications. With these, the amount of calcium present in the sample was determined as shown in the result. (Appendix A3-1).

POTASSIUM

REGENTS:

1. Potassium stock solution 1.907g of potassium chloride was dissolved in litre of water. This contains 1000ppm K.

2. Standard potassium working solution. From the stock solution, a range of standard containing 2,4,6,8 and 10ppm.

PROCEDURE:

1.0g of each samples was ashed and moisten with water and 10ml diluted hydrochloric acid. The mixture was boiled for several minutes, cooled and filtered into 100ml flask, then diluted to a final volume of 100ml.

The freshly prepared standard working solution was passed through the spectrophotometer at a line 766.5mm using a 10A-cathode lamp. This was to standardise the equipment. After standardising, the sample solutions were sprayed through the spectrophotometer and readings of concentration of potassium were read as for calcium. With this the quantity of potassium present in the samples were determined. (Appendix A3-2.)

3.2.4 COLORIMETRIC DETERMINATION OF REDUCING SUGAR USING DINITROSALICYLATE METHOD.

REAGENTS:

3, 5 - Dinitrosalicylate (DNS) reagent. 10g 3, 5 DNS dissolve with warming in 200ml double concentrated sodium hydroxide. 300 Rochelle salt dissolved in 500ml water, these two solutions were mixed with constant stirring and diluted to 1.0 litre.

2. Standard glucose + fructose solution containing 0.09g (5mMoles) glucose + 0.09g (5mMoles) of fructose dissolved in 100mls distilled water.

3. Standard working solution: Containing 0.4, 0.8, and 1.2mls standard sugar.

4. Blank - control. Solution.

PROCEDURE.

0.2g of each blended sample was mixed in a flask with 100mls of distilled water. 1.2mls of each sample was then pipetted into different test-tubes labelled A - F. To each test-tube, 2.0mls of DNS was added.

From the standard sugar solution, 0.4, 0.8 and 1.2mls were put into test-tubes and labelled S_1, S_2, S_3, and 2.0mls of DNS was added to each working solution and into a blank test-tube. Water was added to all test tubes to make 4.5mls solution.

The test tubes (sample and standard) were placed in boiling water for 15 minutes after which they were cooled. To each sample and standard 15.5mls of water was added to bring volume to 20.0ml.

The visible region spectro photometer was set to 520nm and set to zero absorbance using the blank standard. Each standard sugar sample solution absorbance level was taken as well as the absorbency level of each sample of vegetables. The reduced sugar content of each sample is determined from the standard graph as shown in the result. (Appendix A4).

4.0 RESULTS AND DISCUSSION.

The tables 4.1 to 4.6 show the result obtained from the analysis carried out on both fresh and dried tomato, sweet pepper and okra.

4.1 VITAMINS.

(a) Table 4.1 Vitamin A content of selected vegetables

		VITAMIN A *µg Retinol equivalent/100µg Edible portion		
VEGETABLE	**BOTANICAL NAME**	**FRESH**	**DRIED**	**DIFFERENCE**
Tomato	Lycopersicum esculentum	65.2	13.04	52.16
S. Pepper	Capiscum annum	99.8	34.80	65.0
Okra	Hybiscum esculentum	17.37	8.67	8.70

(b) **Vitamin A** **PROVITAMIN A**

Vegetable	Retinol Ug/100g		I.U Vit. A Activity		Carotene µg/100g	
	Fresh	Dried	Fresh	Dried	Fresh	Dried
Tomato	65.2	13.04	652.0	130.4	391.2	78.24
S. Pepper	99.8	34.8	998.0	348.8	598.8	208.8
Okra	17.37	8.67	173.7	86.70	104.22	52.02

Table 4.1a shows the Vitamin A content of selected vegetables in this work, while Table 4.1 (b) shows the carotene equivalent values.

The obtained results from fresh vegetable compare relatively within the range of values given in literatures and table 1.1 for fresh tomato and pepper. Value obtained from okra is higher than those in King (1992), but compare with that of Ahigbe (1984). The slight difference can be attributed to ecological variation but the varieties are the same (44-7).

Results obtained from sun-dried vegetables bought from the market show very low values (130.4IU, 348.9IU and 86. IU for tomato, sweet pepper and okra respectively),when compared to daily dietary requirement, as shown in appendix B.

The difference between the values of vitamin A in fresh and locally sun dried vegetables sold in the market is high, 80%, 65.13% and 50% for tomato, sweet pepper and okra respectively. Though there are not much work done on Vitamin A content of sun-dried vegetables, the effects of direct-sun drying on Vitamin A discussed in literature are obvious particularly that these locally dried vegetable were not blanched or sulphited prior to drying. These results equally shows that less than 20% of Vitamin in fresh tomato, 30% of fresh okra and 30% of pepper are available in the dried ones.

Ascorbic acid content of the vegetables analysed are shown in table 4.2

Table 4.2 ASCORBIC ACID CONTENT OF SELECTED VEGETABLES.

		Ascorbic acid mg/100g Edible portion		
Vegetable	BOTANICAL NAME	FRESH	DRIED	DIFFERENCE
Tomato	Lycopersicum esculentum	40.0	10.6	29.40
S. Pepper	Cap iscum annum	104.0	31.52	72.48
Okra	Hybiscus esculentum	34.0	18.20	15.8

The ascorbic acid content of fresh vegetables show a higher value for tomato when compared with most literatures. However, when compared with the value reported by Addo (1983), who worked on the same varieties grown in northern part of Nigeria the values are comparatively close.

TABLE 4.3 COMPARISON OF ASCORBIC ACID VALUES OBTAINED BY ADDO (1983) AND THOSE OBTAINED IN THIS ANALYSIS

Vegetable	Ascorbic acid values Addo (1983)mg/100g		Ascorbic acid Value in this study mg/100g	
	FRESH	DRIED	FRESH	DRIED
Tomato	49.51	Not determined	40.0	10.6
Sweet Pepper	104.32	69.7	104.0	31.52
Okra	47.2	31.7	34.0	18.20

The obtained results for tomato and sweet pepper are comparable, however lower than Addo (1983), value for okra, but compares with Ahigbe (!984) who worked on the same 44-7 okra variety. On dried vegetables, though there was no value to compare that of tomato with, it is however obvious that ascorbic acid loss which is higher in sun-dried product is reflected. Values of the traditionally sun-dried okra of 18.20mg/100g compares with those of Ahigbe (1984), 11.52 - 18.57mg/100g.

The high loss in ascorbic acid content of locally sun-dried market vegetables as compared with market fresh one can be attributed to method of pre-drying and drying processes. Unblanched sun-dried vegetables will lose more ascorbic acid than blanched ones during drying and in store (Jackson and Mohammed (1969). The local farmers do not blanch or sulphite before drying. Another reason that can be attributed to this is the storage method and period. Dried vegetables available in the market stalls have been kept in store and still being stored.

Considering more losses during preparation and cooking of these vegetables (40% during washing, 90% during cooking), King (1992), the amount of ascorbic acid from meals cooked using these dried vegetables will be very low, about 0.6mg/100g for tomato.

4.2 MINERALS

Calcium and potassium contents of analysed vegetables as shown in table 4.4 indicate little change in the mineral contents of dried vegetables.

The obtained values for fresh vegetables are a little lower than those of table 1.1 for okra and sweet pepper, while the value for sweet pepper is quite lower than those obtained by Oyebiodun (1982) It was not specified what variety was analysed in that work. For tomato, the value of calcium for fresh tomato compares reasonably with the value in table. 1.1 and that reported by Fisher (1985), Hamilton et al (1981), and Pyke (1975).

This result comparatively shows that mineral content of vegetables is stable to drying than vitamins as reported by FAO (1968). The slight difference recorded between sun dried and fresh samples can be due to analytical process.

The values obtained for potassium are lower than those obtained in literatures for tomato and okra but higher for pepper. However the values for both fresh and sun-dried vegetable have minimal variation and this could be attributed to analytical processes.

TABLE 4.5 CALCIUM AND POTASSIUM CONTENT OF SELECTED VEGATABLES.

VEGETABLE	CALCIUM (mg/100g)		POTASSIUM (mg/100g)	
	FRESH	SUN-DRIED	FRESH	SUN-DRIED
Tomato	12.0	10.6	179.6	169.0
S. Pepper	22.5	20.4	706.30	693.0
Okra	32266.0	59.8	251.6	242.30

4.3 SUGAR

TABLE 4.6 REDUCING SUGAR CONTENT OF SELECTED VEGETABLES (g/100g Edible portion)

	FRESH	SUN DRIED
Tomato	2.4	14.8
Sweet Pepper	3.6	7.6
Okra	1.6	4.8

The sugar (monosacharides) content of selected vegetables analysed are shown in table 4.5. The values obtain for tomato compares with those by Fisher (1985) and Guthrie (1979).Values of carbohydrates in table 1.1 which include other forms sugar are a little higher than those obtained in this work.

Comparing fresh and sun-dried samples, the latter contains more sugar per edible portion due to the absence of water, which reduces concentration in fresh samples.

5.0 CONCLUSION AND RECOMMENDATIONS.

Sun drying while aiding preservation of vegetables for availability during off seasons was found to account for about 56-75%, 80-50% and 46.5-73.5% differences in pro-vitamin A and Ascorbic acid contents of market fresh and locally sun-dried tomato, sweet pepper and okra.

The result shows that high losses occur through enzymic, oxidative and light degradation mechanisms, especially as they were not blanched and sulphited before drying. These nutrients are further depleted in store before these vegetables are brought to the market. β-Carotene and vitamin C contents of locally sun dried vegetables are low, it therefore means that with further losses during cooking of meals made from them, the vitamins obtained will be insufficient compared to daily dietary requirement. More sugar than vitamins is being consumed from dried vegetables.

Following these, nutrients quality should therefore be an important consideration in sun drying process of vegetable preservation to avert micro nutrient deficiency problems in developing countries including Nigeria.

RECOMMENDATION:

Because Vegetables are valuable micronutrient sources, the following improvement in the present local dehydration of tomatoes, sweet pepper and okra are recommended in the light of the results obtained and reported in the work.

a. Shade drying technique: This will enable the attainment of the following.

(i) Better carotene retention and its storage stability.

(ii) Prevention of brown colours after drying. Shade drying follows the same basic technique as in sun drying, except that materials are not exposed to direct sunlight. Locally, this can be achieved by placing materials under roofed or thatched open end structures (sheds) used on the farm, provided there is good air circulation, shade drying requires little additional time than for sun drying.

b. Pre-drying operations such as slicing, blanching and/or sulphting. For large scale production, slicing machines to aid farmers should be developed. Slicing will reduce drying time thus loss of vitamins.

Steam blanching should be carried out for okra. This can be achieved by placing sliced okra tray in boiling pot of water for about six minutes using appropriate devices. This will stop enzymic reactions during and after drying, loss of vitamins, hence retain good quality.

While sulphiting is important to improve carotene retention, appropriate adaptable and sustainable techniques should be developed.

b. Sanitation and hygiene. Low cost hygienic drying trays or surfaces should be adopted to avoid dirt, foreign particles, and insect infestation.

FURTHER WORK

The results recorded in this work are functions of many factors. These include drying processes and methods, drying temperature, time and pre-drying operations. Further work should be done to

(i) investigate the effects of different drying methods, varying drying temperature and time on vitamin retention of these selected vegetables

(ii) The use of column –chromatographic method of β-carotene analysis should be investigated, if the facilities are available, this may give a better result.

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APPENDIX A1: VITAMIN A ANALYSIS RESULT AND CALCULATIONS

Absorbance Level Reading

Vegetable	FRESH					DRIED				
	R_1	R_2	R_3	XT_1	XT_2	R_1	R_2	R_3	XT_1	XT_2
Tomato	0.277	0.318	0.272	0.289	0.28885	0.249	0.179	0.317	0.248	0.2479
Pepper	0.343	0.365	0.303	0.337	0.33672	0.299	0.298	0.277	0.287	0.28798
Okra	0.275	0.377	0.404	0.352	0.3519	0.1960	0.222	0.171	0.196	0.19594

S_1 = 1.27

S_2 = 0.58

Absorbance of standard before exposure to ultraviolet lamp = S_1 and after exposure = S_2

Absorbance of samples before exposure to ultraviolet lamp = T_1 and after exposure = T_2

Vitamin A concentration (µglml)

$$= \frac{T_1 - x\ T_2\ x\ \text{Dilution factor}}{S_1 - S_2}$$

Dilution factor D.F = 1000

$S_1 - S_2$ = 1.27 - 0.58 = 0.69

Example Calculations

(Tomato)

Vit A = 0.289 - 0.28885 x 1000 / 0.69

= 0.2174 µg/ml

= 0.2173 x 15 x =, 3.26 µg/5g

These values are multiplied by 20 to obtain µg/100g edible portion

APPENDIX A3 Concentration of calcium contained in selected vegetables (mg/100g).*

CONCENTRATION mg/g

SAMPLE	FRESH				DRIED			
Vegetable	R_1,	R_2	R_3	X	R_1	R_2	R_3	X
Tomato	0.12	0.12	0.12	0.120	0.106	0.107	0.105	.106
Sweet pepper	0.23	0.202	0.24	0.224	0.20	0.22	0.192	0.204
Okra	0.66	0.64	0.68	0.66	0.55	0.60	0.64	0.594

*Multiply values by 100g to obtain mg/100g edible portion.

APPENDIX A3II: Concentration of potassium contained in selected vegetables (mg/100g) .

CONCENTRATION mg/100g

SAMPLE			FRESH					DRIED
Vegetable	R_1	R_2	R_3	X	R_1	R_2	R_3	X
Tomato	1.91	1.82	1.66	1.796	1.79	1.81	1.47	1.69
Sweet pepper	7.09	7.03	7.07	7.063	6.89	6.96	6.94	6.93
Okra	2.62	2.48	2.45	2.516	2.58	2.22	2.47	2.423

APPENDIX A4: REDUCING SUGAR ANALYSIS RESULT AND CALCULATIONS

Standard working solution concentration and absorbance level

CONCENTRATION	ABSORBANCE
S1 = 0.4 µg/5ml	0.18
S2 = 0.8 µg/5ml	0.36
S3 = 1.2 µg/5ml	0.54

ABSORBANCE

VEGETABLE	FRESH				DRIED			
	R_1	R_2	R_3	X	R_1	R_2	R_3	X
Tomato	0.03	0.03	0.03	0.030	0.18	0.17	0.17	0.173
Pepper	0.05	0.04	0.04	0.043	0.09	0.08	0.07	0.086
Okra	0.02	0.02	0.02	0.02	0.06	0.06	0.05	0.056

From the graph, the concentration of glucose + Fructose in the vegetables are as below.

Reducing sugar content of selected vegetables in mg/ml

VEGETABLE	FRESH		DRIED	
	Absorbance	Sugar µg/100g	Absorbance	Sugar µg/100
Tomato	0.030	0.06	0.173	0.37
Pepper	0.043	0.09	0.08	0.19
Okra	0.02	0.04	0.566	0.12

Example Calculation

Fresh Tomato = 0.06 x 2000 mg/ml

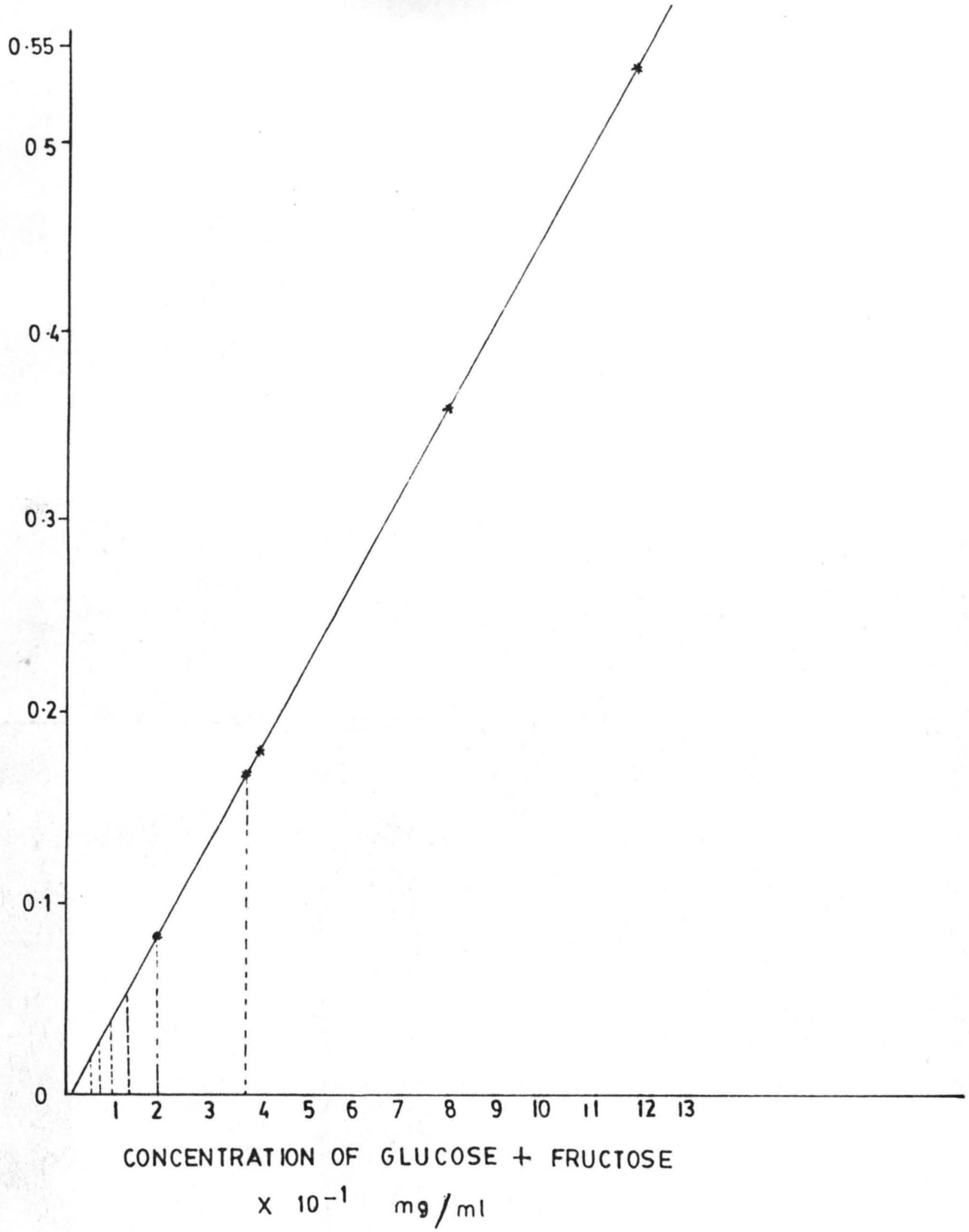
= (0.06 x 2000) mg / 0.2g edible portion

Where 2000 = dilution factor = 120, mg/0.2g

$$\frac{120 \times 100}{5} \text{ mg/100g}$$

= 2.4g/100g

REDUDUCING SUGER ANALYSIS GRAPH



APPENDIX B. DAILY DIETARY ALLOWANCE

			Adult		Women	
Nutrient	Infant 0-1	Children	Males	Female	Pregnant	Lactating
Vitamin A(I.U)	1500	2000- 3,500	2400-2500	4500-5000	6000	8000
Vitamin C(mg)	35	40	40 - 60	40 - 55	60	60
B2 (mg)	5 - 8	8 - 15	14 - 17	13 - 15		
B3 (mg)	0.4 - 0.6	0.6 - 1.2	1.3 - 1.7	1.3 - 1.5	1.8	2.0
B1 (mg)	0.2 - 0.5	0.6 - 1.1	1.2 - 1.5	1 - 1.2	1 - 1.3	1-1.7
Calcium (g)	0.4 - 0.6	0.7 - 1.0	1.2 - 0.8	0.8 - 1.2	0.8-1.6	0.8-17
Phosphorus (g)	0.2 - 0.5	0.7 - 1.0	0.8-1.2	0.8-1.2	0.81.6	0.8-1.7
Iodine (μg)	25 - 45	55 - 110	110 - 150	80-110	125	150
Iron (g)	6 - 15	10 - 15	10 - 18	18	18	18
Magnesium (g)	40-70	100-250	300-400	300-350	452	452
Protein (g)		25 - 40	45 - 65	50 - 55	65	75

Adapted from Encyclopædia of science and Technology Vol.5 pp.