SEASONAL AVAILABILITY OF DIETARY ASCORBIC ACID (VITAMIN C) IN ZARIA DISTRICT OF KADUNA STATE, NIGERIA

BY

ADENIKE ADEJOKE ADDO

B.Sc, University of Ibadan, Nigeria, 1970

M.Sc, Kansas State University, U.S.A.,1973

A THESIS

Submitted in partial fulfillment

of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Biochemistry

Faculty of Science

Ahmadu Bello University, Zaria

NIGERIA

April, I980

THESIS APPROVAL

This thesis by Adenike A. Addo meets the regulations governing the degree of Doctor of Philosophy of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

Internal Examiners

Prof. O. U. Eka
Department of Biochemistry
University of Calabar
Calabar, Nigeria.

Prof. M. M. Rahman
Department of Biochemistry
Ahmadu Bello University
Zaria, Nigeria.

Dr. G. O. Ogbadu
Department of Biochemistry
Ahmadu Bello University
Zaria, Nigeria.

External Examiner

Prof. O. L. Oke
Department of Biochemistry
University of Ife
Ile-Ife, Nigeria.



Date: May 24th 1980

DECLARATION

I hereby declare that all the work in this thesis was carried out entirely by me in the Department of Biochemistry, Faculty of Science, Ahmadu Bello University, Zaria, from 1976 to 1980.

This work has not been presented elsewhere for consideration for award of any degree. The findings of other investigators have been carefully cited and acknowledged in the appropriate parts of the text.

Adenike A. Addo

Adenike A. Addo

ACKNOWLEDGEMENTS

This piece of work has been made possible by the generous research grant by the Ahmadu Bello University Board of Research and I am indeed grateful. I am sincerely grateful to Professor O. U. Eka (University of Calabar, Department of Biochemistry) for his initial advice on the work. I appreciate the continous and generous advice of Professor H. M. Hallaway (Head of the Department of Biochemistry). I sincerely thank Professor M. M. Rahman and Dr. G. Ogbadu both of the Department of Biochemistry for their suggestions and critical review of the thesis. May thanks also go to Mr. M. Elelu of the Department of Biochemistry for his technical assistance.

Thanks to the Department of Biochemistry for making available, laboratory space and equipments to carry out all the phases of the work. I appreciate the cooperation received from medical personnel of the medical centres visited during the course of the survey.

My sincere thanks to my husband Paul and children, Ahonkhare, Esesuwa and Ohirheme for their continual patience and encouragement during the period of research.

RESEARCH

Research should not be limited simply to the gathering of so-called facts. Research is not a mere fact-gathering activity. It is fact-gathering in a co-ordinated manner with interpretative objectives, and setting the facts together in a pattern of relational thinking.

Research raises problems and sometimes solves them. Research observes facts and reveals the meanings underlying them. Research creates tools for use in fact-finding and other practical situations.

Research Scientists should operate on two levels. The level of theory - hypotheses - construct and the level of observation.

F. N. Kerlinger.

TABLE OF CONTENTS

		Page
INTRODUCTION		1-4
CHAPTER I		
ASCORBIC ACID: A GENERAL REVIEW OF LITERATURE AND REFERENCE TO NIGERIA		5
1.	Chemistry of Ascorbic Acid	6-8
2.	Distribution of Ascorbic Acid in Foodstuffs	8-10
3.	Effect of Processing on Ascorbic Acid Contents of Foodstuffs	11-13
4.	Effect of Storage on Ascorbic Acid Contents of Foodstuffs	14-15
5.	Methods of Ascorbic Acid Estimation ...	15-22
6.	Functions of Ascorbic Acid	22-25
7.	Metabolism of Ascorbic Acid	25-27
8.	Ascorbic Acid Requirements by Guinea Pig and Man	27-32
9.	The Distribution of Ascorbic Acid in Animal Tissues	32-34
10.	Ascorbic Acid Deficiency and its effects on Man - (a) Scurvy	35-39
	(b) Non-Scorbutic Effects	39-44

Page

11. Ascorbic Acid - Special Reference to Nigeria 44-48

CHAPTER II

SEASONAL AVAILABILITY OF DIETARY ASCORBIC ACID IN SOME SELECTED RURAL, SUB-URBAN AND URBAN HOUSEHOLDS IN ZARIA DISTRICT 49

Introduction 50-52

Materials and Methods 53-62

Results 62-80

Discussion 81-90

Summary 90-92

Tables 93-113

Figures 114

CHAPTER III

BIOAVAILABILITY OF DIETARY ASCORBIC ACID IN ADULTS 115

Introduction 116-117

Materials and Methods 118-126

Results and Discussion 127-132

Summary 132-133

Tables 134-137

Page

CHAPTER IV

SEASONAL VARIATION OF ASCORBIC ACID CONTENTS OF SELECTED VEGETABLES PRODUCED IN ZARIA AREA 138

Introduction 139-140

Materials and Methods 141-142

Results 142-143

Discussion 143-145

Summary 145-146

Tables 147

CHAPTER V

EFFECT OF COOKING, STORAGE AND REHEATING ON ASCORBIC ACID RETENTION OF VEGETABLE SOUPS 148

Introduction 149-150

Materials and Methods 150-152

Results 152-153

Discussion 154-157

Summary 157-158

Tables 159-161

CHAPTER VI

EFFECT OF STORAGE ON THE ASCORBIC ACID CONTENTS OF DEHYDRATED NIGERIAN VEGETABLES 162

Page

Introduction 163-164

Materials and Methods 165

Results 165-166

Discussion 167-170

Summary 170-171

Tables 172-174

CHAPTER VII

THE INCIDENCE OF CLINICAL SCURVY IN THE NORTHERN STATES OF NIGERIA 175

Introduction 176-177

Materials and Methods 177-178

Results 178-179

Discussion 179-180

Summary 180

Tables 181

CHAPTER VIII

SEASONAL AVAILABILITY OF DIETARY ASCORBIC ACID (VITAMIN C) IN SOME LOCALITIES OF ZARIA DISTRICT KADUNA STATE, NIGERIA: GENERAL DISCUSSION AND CONCLUSION 182-188

Page

REFERENCES 189-207

APPENDIX 208

1. Statistical Analysis; Estimation of t-ratio 209

2. Questionnaire used for Food Consumption Survey 210-214

3. Figures:

2. Mean Annual Rainfal of Nigeria... 215

3. Length of Rainy Season in Northern Nigeria 216

4. Types of Crop Farming in Nigeria..217-218

5. Major Food Crops Peculiar to Certain Parts of Nigeria 219

6. Major Fruits and Vegetables Producing Areas of Nigeria 220

7. Standardization Curve of L-ascorbic Acid 221

8. Standardization Curve for Plasma Ascorbic Acid 222

9. Standardization Curve for Creatinine 223

Page

10. Changes in Plasma and Urinary Level of Ascorbic Acid of Human Subject due to Feeding of "Kuka" Soup as Compared to Supplemental Ascorbic Acid Tablet 224

4. Tables Showing Ascorbic Acid Intake Among Inhabitants of the Rural, Sub-urban and Urban Areas of Zaria District 225-260

5. Tables Showing the Ascorbic Acid Contents of Some Selected Vegetables Grown in Zaria District, 1976-1978 261-264

6. Glossary of Food Terms in Hausa and Recipes for Preparation of Common Foods Peculiar to the Survey Population 265-272

7. List of Hospitals and Other Medical Centres Surveyed for Clinical Scurvy 273-274

ABSTRACT

INTRODUCTION

Fruits and vegetables are the major sources of ascorbic acid in the Nigerian diet. In most parts of the Northern States of Nigeria where sorghum and millet which contain little or no ascorbic acid are the staple food, vegetables constitute the largest source of ascorbic acid because of the relative scarcity of fruits. Some of the vegetables commonly in use are bitterleaf (Vernonia amygdalina), okro (Hibiscus esculentus), sorrell leaf (Hibiscus sabdarrifa), baobab leaves (Andasonia digitata) and red peppers (Capsicum sp).

The ascorbic acid values of few of these vegetables and fruits have been reported. According to Oke (1967) the ascorbic acid content of the vegetables, most commonly consumed in Nigeria, ranges from 18 to 98mg/100g of the fresh material. In another study Reiff (1959) reported that fresh citrus fruits contained 40 to 100mg ascorbic acid per 100g, and that locally canned fruit juices may form an adequate substitute in days of scarcity of the fresh fruits, since they are also adequate in ascorbic acid.

The value of any foodstuff as a source of ascorbic acid depends on how much of the vitamin is available at the time of consumption and on the availability of such foodstuff at costs which can be afforded. Losses of ascorbic acid during cooking

and other processing of vegetables have been estimated to range from 46 to 68 per cent (Nicol 1956, Oke 1967, Addo 1973).

A great deal has been published about malnutrition and various nutritional diseases in Nigeria (Bassir 1953, Dema 1965, Omololu 1972). In a survey in Igbo-Ora in Oyo State, Kotnis and Houssain (1974) reported an adequate intake of ascorbic acid among children and pregnant women. Reiff (1959), also confirmed this with outpatients in Ibadan. On the other hand Nicol (1956) reported that the customary diets of 10 to 12 year-old children, living in Kaduna, supplied only small amounts of ascorbic acid during ten months in the year due to shortage of fresh fruits and vegetables. According to the same survey, cases of clinical scurvy are rare despite the long spell of dry season, which makes fresh vegetables scarce.

However, many gaps still exist in tables of ascrobic acid contents of certain foodstuff commonly eaten in Nigeria. Also little is known about the amount of ascorbic acid present in foods at the time of consumption, and the alteration which might have occured due to the native methods of preparation and storage. No work has been reported on the seasonal availability of dietary ascorbic acid in Nigeria. The objectives of this study therefore are:

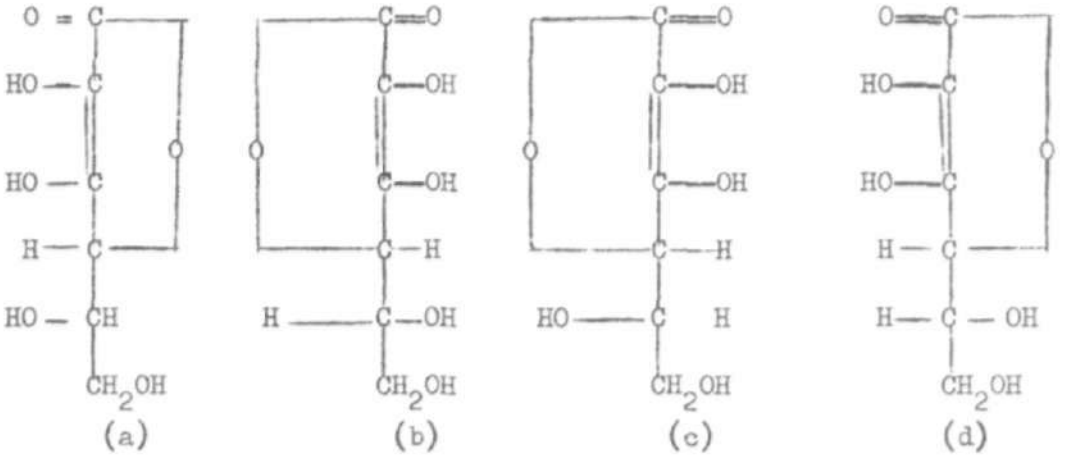
1. To determine the differences, if any, in ascorbic acid intake during the dry and rainy seasons by:
    a) Conducting a dietary survey among selected population groups in rural, sub-urban and urban locations of Zaria district.
    b) Determining the ascorbic acid content of commonly used fruits and vegetables during the two seasons.
2. To determine the effects of methods of cooking, drying and storage on the ascorbic acid retention of vegetables.
3. To determine the bioavailability of dietary ascorbic acid in human subjects.
4. To determine seasonal incidence of clinical scurvy, if any, within the population of the Northern States of Nigeria and correlate these findings with available dietary ascorbic acid in the population.

CHAPTER I

ASCORBIC ACID (VITAMIN C): A GENERAL REVIEW OF LITERATURE AND REFERENCE TO NIGERIA

CHEMISTRY OF ASCORBIC ACID

Vitamin C or ascorbic acid (I - threo - 2, 4, 5, 6 pento-hexane - 2 carboxylic acid) is a hexose derivative and classified as a carbohydrate. It behaves like a monobasic acid; this property stems from the two enol groups; the two asymetric carbon atoms (C_4-C_5) in ascorbic acid make four stereo isomers possible. These are conveniently distinguished as belonging to either the xylo or arabo series (with carbons 4 and 5 having the opposite or the same configuration, respectively) and to either the D- or L- series as determined by the absolute configuration at carbon 5. The diagrams are shown below.



(a) L - ascorbic acid (b) D - ascorbic acid (c) L - ascorbic acid

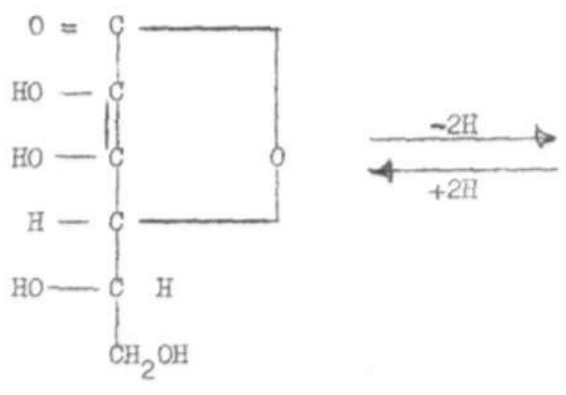
(d) D - Isoascorbic acid

(L - xyloascorbic acid, vitamin C) (D - xyloascorbic acid) (L - arabo-ascorbic acid) (D - araboascorbic acid).

Properties of ascorbic acid

L - ascorbic acid is a crystalline white solid with a specific rotation in water of +23°, melting point 192°C. It is soluble in water, alcohol, glycerol and propylene glycol but insoluble in oils, fats, ether and chloroform. It is unstable to oxidising agents, alkalis and certain metals, e.g. iron and copper salts, but stable in acid solutions below pH 4.0.

L - dehydroascorbic acid is the first oxidative product of ascorbic acid. This reaction is reversible since (-dehydroascorbic acid can be converted to L- ascorbic acid by reduction with hydrogen sulphide or hydrogen iodide. Further oxidation of L- dehydroascorbic acid leads to extensive degradation with the formation of oxalic acid.



Ascorbic Acid

$C_6H_8O_6$

Dehydroascorbic acid

$C_6H_6O_6$

Ascorbic acid will also reduce cytochrome C, and this is the basis of many previous cytochrome assays. Beastle (1974) reported on the antioxidant action of ascorbic acid in beer. He found that on industrial scale, two gm ascorbic acid per hectalitre of beer preserved the colour and flavour during storage for 66 days.

DISTRIBUTION OF ASCOBIC ACID IN FOODS

Investigations of the occurrence of ascorbic acid in food-stuffs have been facilitated by the comparative simplicity of chemical methods for estimation of the vitamin. With the exception of some animal products like kidney, liver, only fruits and vegetables contribute natural vitamin C to the diet. Synthetic ascorbic acid may, however, be added to some edible products either for the purpose of fortification or as a processing agent, for example, as an antioxidant, and the possibility of such addition should be borne in mind in dietary assays (Wilson et al., 1974).

The distribution of ascorbic acid within one individual fruit or vegetable is often extremely variable. For example a greater concentration of the vitamin is usually found in the skin as compared with the pulp of fruit, and significantly different values may exist between leaf and petiole or between two leaves on the one green vegetable. Similarly individual plants such as

cabbage, of identical variety and of adjacent growth may have significantly different average contents of ascorbic acid. Some seed-containing tissues, e.g. black currants and peas, show striking changes in concentration of ascorbic acid during maturation, but in storage organs such as potatoes and leaves such as spinach, the average level remains relatively constant throughout the growth period (Merck Service Bulletin, 1956). Takama et al. (1973) reported that as cucumbers became bigger moisture content increased, total ash, ascorbic acid and chlorophyll contents decreased. As sweet peppers grew, the moisture content increased, ash and chlorophyll contents decreased, and ascorbic acid content increased.

Heights above sea level at which chestnuts were grown had a slight influence on the ascorbic acid. Zadorozhnyi (1974) reported that at 71,200 metres, range of mean contents was 30.13 - 35.34 mg % versus 31.32 - 36.03 mg % at 300 - 400 metres and 34.41 - 37.79 mg % at 500 - 600 metres. Mangalam and Mudambi (1972) studied the effect of variety, ripening stage and fruit size on the ascorbic acid content of fruit bought fresh from Bombay (India) markets and analysed the same day. They reported that in citrus fruits ascorbic acid content decreased with increase in fruit size and peeled orange segments contained more ascorbic acid than the juice.

Unripe tomato and pimento fruit showed low ascorbic acid contents which increased progressively with growth (Kitagawa, 1973).

Once maturity had been reached, the ascorbic acid content of tomato began decreasing whereas that of pimento continued to increase. Within each fruit, the ascorbic acid content was highest in the apical region and diminished progressively in areas proximal to it in the case of pimento and strawberry. In tomatoes, the proximal region exhibited a particularly high ascorbic acid content. Considerable quantities of ascorbic acid were found in both the fruit wall and seeds of 5 coffee types (Vasudeva and Gopal, 1972). Ascorbic acid was significantly greater in seeds than in fruit wall of all types. Kitagawa (1973) reported that during the later stages of growth, light-coloured plants such as onions showed a marked fall in ascorbic acid concentration while the green coloured plants such as lettuce and carrot leaves maintained a comparatively high level of ascorbic acid.

Ascorbic acid content of field-grown tomatoes increased to a maximum when almost the whole fruit had turned red and declined in overmature fruit. For distribution, most tomatoes are picked when mature green, transported and ripened at distant markets; this was shown to reduce their ascorbic acid to 25 - 30% tomatoes matured on the plant. With artificial ripening of mature green tomatoes, ascorbic acid content was 20% higher with ripening under white fluorescent light than in darkness (Markakis et al. 1974).

EFFECT OF PROCESSING ON ASCORBIC ACID CONTENT OF FOODSTUFFS

The high solubility of ascorbic acid in water and the relative ease with which it is oxidised, either chemically or enzymatically, makes this vitamin particularly susceptible to processing condition, especially when the tissue is broken or when the temperature is raised. Slicing, cutting or bruising of fruits and vegetables before processing is therefore likely to result in loss of ascorbic acid, especially associated with high-temperature treatment in air, water or steam. Extraction of the vitamin takes place rapidly, under normal conditions of boiling, and continues until the concentration of vitamin in the liquor approximates that in the tissue. If vegetables are steamed or pressure cooked instead of boiled, the leaching effect is negligible, but a greater loss of vitamin is to be expected from oxidation especially with green vegetables (Sood and Bhat, 1974).

Keeping drained vegetables hot for an extended period before serving is to be discouraged from the nutritional standpoint, since progressive oxidation of vitamin has been found especially when the tissue is finely cut or divided, as with chopped green vegetables (Herrman et al. 1974).

The retention of ascorbic acid was investigated in leaves of Manihot Utilissma (cassava) and Basella rubra (ceylon spinach).

When leaves were boiled in water, cooked in coconut milk or fried, ascorbic acid retention was 45, 56 and 66% immediately after cooking, 30, 46 and 53% after standing for 4 hours at room temperature. Most of the loss was due to leaching of ascorbic acid into the cooking liquid (Caldwell and Gim-Sai, 1973).

Effects of steaming, braising, boiling and pressure cooking on ascorbic acid content of Koll'rabi, Brussels Sprout, Cauliflower, beans and potatoes were studied (Herrman et al. 1973). Retention after steaming was 80 - 85%, except for beans for which it was 65 - 75%. Corresponding values for braising were 70% and 50 - 60%. Losses on boiling were higher, largely because of passage of ascorbic acid into the cooking water. The effects of common household additives to blanching and/or cooling water on the ascorbic acid retention of runner beans, peas, spinach and Brussel sprouts were studied by Hudson et al. (1974). Ascorbic acid analyses for thawed frozen sprouts blanched in 1.2% NaCl or 1.2% sucrose showed that the treatments did not lower the ascorbic acid content.

Changes in L - ascorbic acid and L - dehydroascorbic acid during boiling of peeled or unpeeled potatoes in distilled or tap water containing various concentration of sodium chloride, and during frying of 3 - 6 mm slices in sunflower-seed oil at 140°C

for 10, 20 and 30 minutes or at 180°C for 5 minutes were determined by Domah et al. (1974) using polarographic method. Results indicate an average loss of 6% as a result of peeling the potatoes. Cooking unpeeled potatoes in distilled water reduced total vitamin C content from 62.8 mg/100 g to 56.1 mg/100 g against 62.3 mg/100 g for raw peeled potatoes. Increasing concentration of sodium chloride caused a decrease of L - ascorbic acid content in potatoes. Total ascorbic acid content was reduced from 26.1 mg/100 g for peeled potatoes cooked in water to 14.7 mg/100g for potatoes cooked in 10% sodium chloride. A small decrease in ascorbic acid occurred during frying; 18% was destroyed during 30 minute frying at 140°C. Ascorbic acid keeps remarkably well in frozen foods, apart from the losses incurred in the preliminary blanching process. Noble and Gordon (1964) showed that broccoli and beans cooked fresh, retained 50% of their ascorbic acid while the blanched product, stored for 6 months at 0°F, retained 30% of this vitamin after cooking. Eheart (1967) reported that broccoli lost 35% of its ascorbic acid during blanching, 7% during freezing and storage for 52 weeks and a further 10% on cooking.

EFFECT OF STORAGE ON ASCORBIC ACID CONTENT OF FOODSTUFFS

Post harvest storage will affect the antiscorbutic value of the raw fruit or vegetable to a degree commensurate with the time and temperature of storage, extent to which the cellular tissue may be damaged, structure of fruit or vegetable, and presence or absence of ascorbic acid oxidase in the tissue. Most soft berry fruits and green vegetables, such as spinach, usually show a rapid fall after harvesting, whereas hard fruits and root vegetables and the tightly packed leaves in a head of cabbage can be stored for several days without loss. With long-term storage, root vegetables show a progressive fall in ascorbic acid content (Bangerth, 1973; Kim et al. 1973; Bolin and Stafford, 1974; Davidek et al. 1974; Jedrzejezyk, 1974; Moser et al. 1974; Ramasastri, 1974; Thomas, 1975).

Ascorbic acid content of fruits and vegetables is slowly lost during storage and is a useful index of freshness. During 1971-1973, the keeping quality of four varieties of melon and three varieties of water melon stored in a ventillated store on shelves bedded in shavings or straw was studied by Mikhailov (1974). Results indicated that water melon stored on shelves or in shallow trenches had the highest contents of total sugar and ascorbic acid.

The effect of cultural practices, locations, soil texture and storage conditions on the ascorbic acid content in Russet Burbank potatoes was investigated by Augustin et al. (1975). The most consistently significant factor affecting ascorbic acid values was storage time. Losses in ascorbic content over a storage period of 240 days at 7.21°C and 95% relative humidity averaged 67%. Losses occurred at faster rates during the first weeks than in the latter part of the storage season.

METHODS OF ASCORBIC ACID ESTIMATION

Biological Assay

The experimental investigation of scurvy began in 1912 with the recognition that the guinea pig required this vitamin (Holst and Frolich, 1912). An assay based on the minimum amount of the vitamin administered daily to prevent or cure scorbutic symptoms in guinea pigs was used during the isolation and early studies of ascorbic acid. The diagnosis and rating of the lesions produced depended considerably upon the experience of the investigator. This method was later replaced by more objective methods, depending upon the dental histology or upon the curative growth rate.

The derangements in dental histology produced by scurvy provide the most sensitive and specific method of bio-assay. In a standard version of this method, groups of animals are fed graded levels of the test substance and of ascorbic acid for a period of 2 weeks, and then sections are made of the decalcified lower incisors. The degree to which the odonoblasts become disorganized, the scarcity and irregularity of dentine deposition, and the degree of hypercalcification of the predentine can be precisely compared with the effects of standard amounts of ascorbic acid (Coward, 1947).

The curative method involves the use of a scorbutogenic diet for ten days. On the eleventh day when weight loss would be expected to begin, groups of animals are placed on graded doses of the test sample and the ascorbic acid, and the biological value of the sample is calculated from the resultant dose response curves (Harris and Oliver, 1942). The bioassay methods have since been almost entirely replaced by the more rapid and convenient chemical assays of ascorbic acid.

Physical Methods

The simplicity of the chemical methods for estimating ascorbic acid has diverted attention from the several physical methods available for measuring ascorbic acid.

Polarography has had limited use in the estimation of ascorbic acid, since early investigations disclosed no advantage over the simpler methods of chemical titration, even as regards specificity. Recent applications of this method have been proposed by Davidek et al. (1971), Kajita et al. (1973). The method is based on oxidation of ascorbic acid to dehydroascorbic acid with bromine, formation of dehydroascorbic acid - O - phenylenediamine in acetate buffer. Polarography has been used successfully for the determination of ascorbic acid in meat and meat products (Davidek et al. 1971), potatoes (Davidek et al. 1974), tomato juice (Chelkowski and Bielinski, 1974).

A gas liquid chromatography method for L - ascorbic acid in foods and food products has been devised (Juergen, 1968; Petrovick et al. 1968; Schlack, 1974). Ascorbic acid is extracted into an ethanol solution, precipitated with lead acetate, regenerated from lead salt as its trimethylsilyl derivative and chromatographed on a SE - 30 column. With this method recoveries of ascorbic acid has been averaged at 100.1% with standard deviation of ± 0.23%.

Chemical Methods

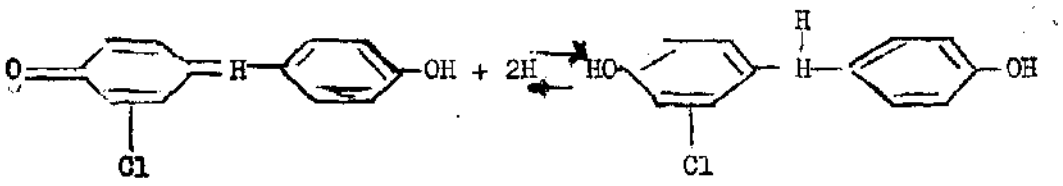
The most satisfactory chemical methods for ascorbic acid analysis are based on the reduction of 2, 6 - dichlorophenol

indophenol or on the formation of a coloured dinitrophenylhydrazine derivative. There are different ways of preparing sample extracts. There is no ideal method equally applicable to the great variety of animal and plant tissues which have been studied. The extraction should avoid the oxidation of this labile compound by the enzymes in the plant tissues or by the oxyhemoglobin and trace metals in animal tissues. It should extract the ascorbic acid completely and should extract a minimum of other tissue components which would interfere with the chemical assay to be used. The single extraction procedure which has found the widest application to both plant and animal tissues is one using metaphosophoric acid, which precipitates proteins, combines with trace metals, and produces an acid medium in which ascorbic acid is most stable (Knox and Goswami, 1961). However, a great variety of other reagents alone or in combination such as oxalic acid, acetic acid and Trichloroacetic acid have been used successfully for particular purposes.

Reduction of 2, 6 - dichlorophenol indophenol

Dichlorophenol indophenol is blue in neutral solutions and pink in acid solutions. Its use in the estimation of ascorbic acid

is based on the observation that ascorbic acid is essentially the only substance in acid extracts of tissues which reduces the dye at pH 1-4 to the colourless leuco form (Schaffert and Kingsley, 1955).



Oxidized form (blue or pink) — Reduced or leuco form (colourless)

Modifications to increase the specificity of the indophenol method have been presented by Robinson and Stotz (1945), Lowry, et al. (1945). However, all these procedures require tedious photometric measurement in 5 and 10 second intervals to determine the rate of reduction of indophenol by l - ascorbic acid.

Dinitrophenylhydrazine Methods

The dinitrophenylhydrazine methods are very sensitive and remarkably specific and are the methods of choice for most analyses (Knox and Goswami, 1961). The reaction depends upon the coupling of 2, 4 dinitrophenylhydrazine to the keto groups of carbons 2 and 3 of diketogulonic acid to form a bis 2, 4 dinitrophenylhydrazone or

osazone. In strong acid solutions this derivative rearranges to a stable reddish-brown product which can be measured photometrically. Ascorbic acid must first be oxidised to dehydro-ascorbic acid for this reaction to occur, and it is probable that dehydroascorbic acid is hydrolysed in the strong acid medium to diketogulonic acid before the hydrazone formation takes place (Roe and Keuther, 1943). Bolomey and Kemmener (1946, 1947) have omitted thiourea in the incubation period and have substituted glacial acetic acid in place of sulphuric acid in the final colour development. This gives clearer samples to read in the colorimeter, but has the disadvantage of only half the sensitivity of sulphuric acid.

Other carbohydrate materials react with dinitropheylhydrazine slowly in comparison with the oxidation products of ascorbic acid, and their osazones are unstable in the high acid concentration used. The addition of the reducing agent, thiourea or stannous chloride, further adds to the specificity of the method by avoiding interference from nonascorbic acid chromogens. Interference has been noted, however, in the analysis of heat-processed foods with a high sugar concentration, presumably because of the high concentration of "reductones" which also affect the dichlorophenolindo phenol reduction assay. A particular advantage of the dinitrophenylhydrazine method is that by appropriate oxidations and

reductions of the sample, each of the three compounds, ascorbic acid, dehydroascrobic acid and diketogulonic acid, can be determined by difference.

A study of the phenylhydrazine procedure of Roe and Kuether was undertaken by Schaffert and Kingsley (1955) to adapt the method for routine analysis of biological samples, mainly by shortening the incubation period of 3 to 6 hours outlined by the original investigators. In the modified procedure, the incubation period is reduced to 5-10 minutes by carrying out the operation at 100°C. Excellent accuracy was demonstrated by recovery experiments, Meyer et al. (1952) confirmed these observations.

N - Bromosuccinimide Method

The presence of pigments especially those absorbing light at about the same wavelength as does 2:6 dichlorophenolindophenol or 2:4 dinotrophenylhydrazine may interfere with determination of ascorbic acid. Barakat et al (1955), proposed a new titrimetric method for the estimation of ascorbic acid using N - bromosuccinimide. It readily oxidises an aqueous solution of ascorbic acid to dehydro-ascorbic acid, while it is irreversibly reduced to succinimide with the formation of hydrogen bromide. This reaction proceeds until

all the ascorbic acid in the solution is oxidised. Excess of N - bromosuccinimide added after all the ascorbic acid content has been oxidised will liberate iodine from potassium iodide which is detected by a brown ring in the ether layer. Evered (1960) and Barakat and Abdalla (1965) confirmed the reliability of this method and showed that the reagent is unaffected by reductones, reductic acid and iron salts.

FUNCTIONS OF ASCORBIC ACID

Ascorbic acid is multifunctional and is involved in many aspects of human physiology, some of which are still poorly understood. Reactions involving ascorbic acid as a carrier for hydrogen transfer have been demonstrated in plant tissue, and the existence of those reactions in animal tissues has been postulated. Ascorbic acid is known to function as a reducing agent for example it acts as a hydrogen reduction of ferric iron to the more easily absorbable ferrous ions (Henley et al. 1956; Brise and Hallberg, 1962; Apte and Venkatachalam, 1965).

Abnormalities of connective tissue observed in scurvy have long suggested that ascorbic acid is involved in the synthesis of collagen or mucopolysaccharides. There is now ample evidence to

support a role of the vitamin in collagen biosynthesis first suggested by the studies of Robertson and Hewitt (1961), Stone and Meister (1962) demonstrated that the vitamin is necessary for the hydroxylation of proline to form hydroxyproline, an unusual amino acid which occurs almost exclusively in collagen. In in vitro studies, Gottliev et al. (1966) recently presented evidence of a collagen - like protein containing little hydroxyproline which is formed in response to ascorbic acid deficiency or when hydroxylation is impaired by lack of oxygen. This low hydroxyproline molecule may be responsible for the structural changes observed in scorbutic tissues.

Ascorbic acid is required for the conversion of folic acid to folinic acid in vivo and in vitro. Although the exact role of ascorbic acid in the folic-folinic acid interconversion is still unknown, the interplay of these vitamins is illustrated by the observation that megaloblastic anaemia in the vitamin C deficient monkey can be cured either by ascorbic acid or folinic acid (Merck Service Bulletin, 1956).

In relation to other nutrients, ascorbic acid has been demonstrated to afford a significant sparing or protective effect on several vitamins in the B - complex including thiamine, riboflavin, folic acid, and pantothenic acid and on vitamins A and E.

The effects appear to depend on its reducing or antioxidant action (Wilson et al. 1974).

A relationship between ascorbic acid and the oxidation of the amino acid, tyrosine, has been observed in guinea pigs and infants but not in adult man. In scorbutic guinea pigs and infants it has been demonstrated that tryosine is not metabolized normally unless sufficient ascorbic acid is available. In adults, however, this relationship was not observed when subjects were fed small amounts of the vitamin and large amounts of the amino acid (Steele et al. 1952). The role that ascorbic acid plays in the metabolism of tyrosine appears to be that of a co-enzyme. The interruption of tyrosine degradation at the stage of ρ - hydroxyphenylpyruvate (pHPP) in scurvy has long been considered the clearest evidence of a biochemical role for ascorbic acid. The intermediate accumulates and is excreted when doses of tyrosine are given to scorbutic man, other primates, guinea pigs and premature infants (Knox, 1955). Ascorbic acid administration prevents the excretion of the intermediate. The isolated pHPP oxidase of liver under certain conditions requires ascorbic acid or related compounds for its continued activity.

The cortical tissue of the adrenal glands contains a high concentration of ascorbic acid. Here, too, are found large

amounts of cholesterol, the proposed parent substance of the cortical hormones probably indicating the role of this vitamin in synthesis of cortical hormones. Studies with guinea pigs have convincingly shown that the most critical effect of a chronic dietary inadequacy of ascorbic acid on cholesterol metabolism is impairement of bile acid synthesis; this leads to the accumulation of cholesterol in the plasma and tissues (Banerjee and Singh, 1958; Ginter et al. 1972, 1974; Ginter, 1975). Equally good experimental evidence suggests that the integrity of the vascular wall is directly altered by an inadequate intake of ascorbic acid (Myasnikor, 1958; Sokoloff et al. 1966; Ginter et al. 1969; Nambisan and Kurup, 1975). These effects imply that chronic dietary insufficiency of vitamin C must be considered a risk factor in the pathogenesis of atherosclerosis.

METABOLISM OF ASCORBIC ACID

Ascorbic acid taken in the food is absorbed into the blood stream chiefly from the intestine within a few hours after it is ingested. The level of ascorbic acid in the blood plasma is increased only temporarily because this substance is taken up by the tissues, and any excess is excreted promptly by the kidneys.

In man ascorbic acid is partly excreted unchanged and partly as diketoL-gulonic acid and oxalic acid. Hellman and Burns (1958) using labelled ascorbic acid, found 12 to 24 per cent of the urinary C^{14} activity in L-ascorbic acid, 12 to 18 per cent in diketogulonic acid and 24 to 63 per cent as oxalic acid in several experiments with three subjects. No C^{14} was detected in respiratory CO_2. This finding is also confirmed by the work of Tolbert et al. (1967); Baker et al. (1966). The vitamin exists in the body in an equilibrium between the reduced and the oxidised (dehydro) states, with only a small fraction in the latter form. The oxidised form can be either reduced to ascorbic acid reversibly, or metabolised to diketogulonic acid irreversibly. It appeared that ascorbic acid and dehydroascorbic acid were almost equally well utilized by man (Sabry et al. 1958).

Oxalate and ascorbic acid in urine accounted for about half the total ascorbic acid turnover in an adult man in the experiments of Atkins et al. (1964) using C^{14} - tagged ascorbic acid. Most of the oxalate was shown to arise from ascorbic acid or glycine. Oxalate arises from carbons 1 and 2 of ascorbic acid (Banay and Dimant, 1962).

Rats and guinea pigs metabolise the carbon chain of ascorbic acid, producing principally CO_2 and oxalic acid, although pathway differences in these species are established (Burns et al. 1958).

Chan et al. (1958) found that guinea pig liver preparations formed dehydroascorbic acid which was degraded to oxalate, CO_2 and L - xylose. No xylose was found from the catabolism of ascorbic acid by rat kidney in studies by Burns et al. (1958).

The half life of ascorbic acid in the guinea pig is only a few days, while in man it has been estimated to be about 16 days (Hellman and Burns, 1958). This may account for the long period required to produce a deficiency state in man compared to the time involved to produce symptoms in the guinea pig.

ASCORBIC ACID REQUIREMENT BY GUINEA PIG AND MAN

Estimates of ascorbic acid requirements can be small, for the amount to maintain histologically normal teeth in the guinea pig, or large for the amount necessary to maintain blood levels equal to those of animals who synthesize their own ascorbic acid. The limits of the minimal protective dose against scurvy and the saturating dose are well known in guinea pig and man. Numerous quantitative studies have been carried out to determine better criteria for establishing more exact requirements (Wilson et al. 1974).

Guinea pigs

The requirements of the guinea pigs have been set between 0.4 and 2 mg per animal per day (Mannering, 1949; Lloyd and Sinclair, 1953). Two studies using a natural ration (Crampton et al. 1944) and a complete purified diet (Collins and Elvehjem, 1959), agreed on the larger requirement of 0.5mg ascorbic acid per 100g body weight per day. It is significant that the total requirement is proportional to body size. Variation of the total requirement has been attributed to additional factors besides body size. Female guinea pigs are said to be more susceptible to scurvy than males, possibly indicating a higher ascorbic acid requirement for females (Beaton et al. 1960). The ascorbic acid requirement is also increased after administration of iodinated casein, but not by thiouracil (Pfander, 1952; Mascitelli and Malocchi, 1954). Continued treatment of guinea pigs with cortisone or ACTH did not alter their ascorbic acid requirement (Harris et al. 1955).

Accurate study on ascorbic acid requirement in pregnant guinea pig is however, lacking. In infections the requirement for ascorbic acid has been reported to be altered because of increased leucocytosis, fever and phagocytosis (Nungester and Ames, 1948).

Human requirements

The National Research Council of U.S.A. has suggested a vitamin C intake of 75-100mg per day for optimum human nutrition. This is the amount necessary to maintain tissue saturation and plasma vitamin C levels of 1mg% without excess loss in urine. British nutritionists set 30mg as the "standard daily requirement" (Wilson et al. 1974). The more generous U.S.A. recommendations are based on the allowances which permit tissue storage within the tissue of animals which synthesize, and therefore do not require, a dietary source of the vitamin. In fact careful experimental work indicates that 10mg daily is sufficient to prevent scurvy and maintain good healing properties of tissues for a period of a year, even if plasma ascorbic acid levels are zero and white cell levels almost zero (Wilson et al. 1974). Requirements for ascorbic acid established in Great Britain, United States of America, Canada cannot always be applied absolutely to everywhere because of marked variations in average normal body weights among peoples of different races and socio-economic conditions coupled with the differences in physical activities and environmental conditions. It is therefore obvious that tables of nutritional requirements or allowances would vary from one country to another. In Nigeria the mean annual

temperature is 25°C. Computation shows that the Nigerian Reference Man and Reference Woman would need 30mg ascorbic acid daily (Idusogie, 1971). This compares favourably with the British standard but is much lower than the American standard. A study was made of 552 school children aged from 8 to 11, in 6 elementary schools in Louissiana in the winters of 1950 and 1951 (Dallyn and Moschette, 1952). Serum ascorbic acid values were obtained for 463 children and 7-day dietary records were kept for 454 children. All the children were examined for gum changes indicative of vitamin C deficiency. About one-half of the serum values for ascorbic acid were 0.6mg per 100ml or over and about 60% of the children were receiving 60mg or more ascorbic acid daily. There was a highly significant correlation, between ascorbic acid intake and serum level, and a significant association between the degree of gum change and the serum ascorbic acid level.

A review of recent work on vitamin C requirements suggests from 30-50mg per day for adults (Ketz, 1970). From the work of Srikantia et al. (1970) with 19 healthy volunteers aged 16-45 years given 500mg ascorbic acid per day it was concluded that adequate levels of tissue ascorbic acid can be maintained on intakes of between 12 and 22mg per day.

The relevance of various measurements to the nutritional status for ascorbic acid in humans has been the subject of much controversy and now it is generally accepted that the level of ascorbic acid in leucocytes (and platelets) of the buffy layer provides the most reliable index of vitamin C nutrition and of tissue saturation than is the content of the plasma or whole blood (Griffiths et al. 1967; Andrews, Letcher and Brook, 1968).

Another traditional method for the assessment of ascorbic acid deficiency is the measurement of urinary excretion levels at relatively high doses of the vitamin. This "saturation" test is fraught with difficulties, not least, that supplemented individuals excrete in the urine, a substance which reacts chemically as ascorbic acid but which has not yet been identified. The two compounds have been separated by thin-layer chromatography (Hodges et al. 1969).

Urinary measurements may also be complicated by a variable, renal threshold or an increase in requirement and utilisation (Andrews and Brook, 1969). Large oral doses tend to be reflected rapidly in the plasma and subsequently in the urine without necessarily reflecting leucocyte or tissue saturation. Conversely, low dose supplementation may be carried out over a

long period with a gradual but persistent increase in leucocyte and tissue level without significant urinary excretion. Indeed, there are reports of individuals who appear to be impossible to saturate.

Using the 2-4 diphenylhydrazine method, the leucocyte and platelet ascorbic acid has been shown to be directly proportional to the intake of ascorbic acid (Davey, Wu and Storvick, 1952; Burch, 1961), but this is in contrast to the findings of Disselduff and Murphy (1968). A direct proportionality between leucocyte and total body ascorbic acid has been shown in the guinea pig (Burch, 1961), and it is claimed that there is indirect evidence that this also holds for humans.

THE DISTRIBUTION OF ASCORBIC ACID IN ANIMAL TISSUES

The understanding of the dynamic state of ascorbic acid in animal tissues is essential for the interpretation of the common measurements made clinically. The concentration of ascorbic acid is unusually high in certain tissues for example the concentration in skeletal muscle which makes up most of the weight of the animal body is 3 to 5 times that in the plasma. Distribution in normal guinea pig tissues shows variable concentration of as low as

0.54 in plasma and as high as 166.0mg per 100g tissue weight (Sobotka and Stewart, 1961).

The plasma level of ascorbic acid appears to be one of the lowest concentration existing in the body. It is effectively buffered by extremely high concentrations of ascorbic acid maintained intracellularly by some kind of active process in all the other tissues. Of these, the leucocyte is the most accessible for routine clinical sampling. Some precise measurements of certain parameters of the steady state of ascorbic acid in the body have been obtained from recent studies with isotopically labelled ascorbic acid (Hellman and Burns, 1958; Salomon and Stubbs, 1961). Thus, the total ascorbic acid is about 1.5g for a man not saturated with ascorbic acid.

The effect of age and development on the distribution of ascorbic acid in animals is not striking. During pregnancy and during the rapid growth of young guinea-pigs, more of the vitamin is retained by the animal, as would be expected from the increasing mass of tissue to be supplied (Reid, 1948). The actual content of ascorbic acid fell slightly with increasing age in the human adrenal cortex and pituitary and after an initial fall, remained constant after middle age in the myocardium and skeletal

muscle (Schans, 1957). In general men have been reported to be more deficient in ascorbic acid than women with age (Morgan, Gullum and Williams, 1955; Brin et al. 1965; Brook and Grimshow, 1968). Andrews et al. (1969), reported a significant fall in the leucocyte ascorbic acid level in the elderly in winter. This is not surprising in view of the variation in dietary habits throughout the year.

Dubasova (1971) examined children 1.5 and 14 years who were fed 300mg vitamin C daily. He observed that respective values of ascorbic acid in the blood of 20 healthy children and the urine of 32 children were 0.96mg/100m/and 21mg daily.

In another study conducted by Dodds (1969), it was concluded that in children 4-12 years old there was little difference in the ascorbic acid blood levels between boys and girls, but from 13-20 years old boys had lower values than girls on equivalent intake. Spathis and Hallpike (1961), described in detail vitamin C level in fasting blood from healthy medical students, 11 men and 7 women aged between 20 and 30 years all taking their usual diets. Means and ranges in mg/100ml for men and women were for whole blood 0.507, 0.224 to 0.880 and 0.884, 0.517 to 1.278; for plasma 0.476, 0.196 to 0.876 and 0.897, 0.624 to 1.412. The difference between men and women were significant statistically.

ASCORBIC ACID DEFICIENCY AND ITS EFFECTS ON MAN: SCURVY

Scurvy is a condition due to deficiency of vitamin C in the diet and marked by weakness, anaemia, spongy gums, a tendency to mucocutaneous haemorrhages.

The effects of an acute lack of vitamin C have been recently studied thoroughly by Hodges et al. (1969), American Academy of Pediatrics, 1962; Baker, Suari and Tolbert, 1966; Baker et al. 1971, at the University of Iowa and the U.S. Army Medical Research Nutrition Laboratory, Denver, respectively. Five male prisoners volunteered to be placed on a liquid vitamin C deficient diet for 84 to 97 days. The first symptoms of deficiency seen were fatigue, hyperkeratosis, pink or hemorrhagic skin follicles, haemorrhages in the eye, coiled hairs and gum changes, followed by pains in the joints, dental caries and low blood and urine ascorbic acid levels. Administration of vitamin C overcame all the symptoms eventually.

Scurvy today is a rare disease affecting two different age groups. It occurs in formula-fed infants between the ages of 6 and 18 months whose diets have not been supplemented with added sources of ascorbic acid (Huisman and Jonxis, 1957; Cochrane, 1960) and in man of middle to old age (Grusin and Kincaid-Smith,

1954; Lind, 1960; Joffe, 1961), who are usually bachelors or widowers and who for more than a year have neglected fresh foods. It must be emphasized that in both of these age groups scurvy is only the predominating illness, and almost always there are other deficiencies or disease states. The guinea pig has been the animal of choice in the bulk of the experimental work on the pathological and biochemical defects associated with ascorbic acid deficiency. This animal is highly susceptible to a lack of ascorbic acid and the alterations are known to be similar to those found in human scurvy. Outstanding among the pathological defects found in ascorbic acid deficiency is the failure to deposit intercellular substance.

Ascorbic acid is essential not only for normal wound healing during the early healing period but also for maintenance of scar tissues in later stages; (Hill and Boune, 1958, Abt et al. 1960). They also demonstrated that the vitamin accumulates in scar tissue quickly after a wound and remains for a long time. The connective tissue has the highest concentration of the vitamin.

Ascorbic acid has been found to be required for the production of predentine in tooth. Fullmer et al. (1961), found definite

disorders of ameloblasts to take place at the site where a failure of dentinogenesis occurred. Amelogenesis in the scorbutic guinea pigs fails in the zones devoid of subjacent dentine with defective odontoblasts unlike the normal.

Yale et al. (1969), studied the oral changes in normal and scorbutic guine pigs autoradiographically and found a greater uptake of radioactivity in the periodontal membranes, alveolar bones, and tooth pulps of scorbutic animals than in the normals after administration of ascorbic acid 1-C^{14}. It is therefore agreed that the characteristic feature in scurvy is the defect in synthesis and maintenance of intercellular substance.

Boyle and Irving (1951), observed some hyaline changes in skeletal muscles in chronic scurvy, whereas in acute conditions these were much less common but the sarcolemma was reduced in amount and the muscle fibrils and the sarcoplasma were seen to end suddenly, leaving the endomysial fibres lying between them. In the bones a deficiency results in the failure of the osteoblasts to form the intercellular substance osteoid. Without osteoid, deposition of bone salts is arrested. The resulting scorbutic bone is weak and fractures easily (Follis, 1958).

Anaemia has frequently, but not consistently, been

reported in association with scurvy in clinical cases, both in adults and infants and in experimental scurvy in guinea pigs and monkeys. Severe clinical scurvy and a high degree of megaloblastic anaemia were reported in two patients whose diet had been almost completely devoid of fruit and vegetables. The megaloblastic anaemia responded completely to treatment with synthetic ascorbic acid (Brown, 1955; Neilson, 1960). It was suggested that the anaemia was due partly to lack of vitamin C which reduced conversion of folic acid to folinic acid. This was further confirmed by the work of Will and Murdoch (1960) and Goldberg (1963).

The exact functional role of ascorbic acid in the cellular process is not clearly understood, although this vitamin has been found to be involved in the metabolism of various substances. The deprivation of ascorbic acid leads to the development of several metabolic defects that can be specifically cured by administration of ascorbic acid. Salman and May (1952), reported that scurvy brings about alterations in the protein metabolism, as reflected in the decrease in plasma proteins. A decrease of about 27% in the albumin and an increase of about 11, 7 and 1% in the α, β and Y globulin contents occur in the serum of guinea

pigs maintained on a scorbutogenic diet for 25-30 days. They further reported a lowering of the albumin/globulin ratio by 32% in scurvy. An abnormally high urinary excretion of a - amino nitrogen and glycine conjugates by vitamin C deficient infants was reported by Jonxis and Wadman (1951), Huisman and Jonxis (1957). Evidence of a possible ascorbic acid deficiency in a premature infant resulting in hyperaminoaciduria has also been reported by Dustin and Bigwood (1953). In view of the fact that an aminoaciduria occurs in all premature infants, to a lesser degree in full-term infants, and only diminishes later during childhood, it is doubtful that these studies demonstrated any additional aminoaciduria due to ascorbic acid deficiency.

NON-SCORBUTIC EFFECTS OF ASCORBIC ACID DEFICIENCY

In the absence of clinically recognizable scurvy, low total white-cell levels of ascorbic acid have been found in various groups, in whom the values can be raised to those of normal young adults by ascorbic acid supplementation. This suggests that the causes are due to low intake rather than multiple pathology; however, the low intake may be caused on occasion by gastro-intestinal pathology (Cohen and Duncan, 1967).

Andrews and Brook (1966) reported low leucocyte vitamin C level in the elderly. Supplementation of the diet improved the blood plasma level to values normally found in younger persons (Alder, 1957). Burlina (1956) investigated ascorbic acid metabolism in old age and reported that saturation was achieved in from 12 to 16 days with 500mg ascorbic acid daily given by mouth, compared with from 5 to 7 days for younger subjects. After saturation blood values remained high for about 5 days, and up to 10 days in 4 subjects, compared with at least 3 weeks in younger adult subjects. Griffiths et al. (1966) in a geriatric survey of patients admitted to hospital, indicated chemical evidence of deficiency in 41%. However, in the elderly at home, the figure was 27%. Brocklehurst et al. (1968) studied 80 geriatric hospital patients for one year and concluded that there was definite evidence of deficiency in many elderly people in hospital for long periods. In a New Zealand dietary survey, low intakes of ascorbic acid were reported in 35 elderly men living alone (Maclean et al. 1976). This low intake was mainly due to low intakes of fresh fruit (particularly citrus fruit) and the cooking methods of vegetables. High significant correlation between dietary ascorbic acid intake and plasma concentration was

also reported.

Many reports have recently indicated a possible association between cigarette smoking, related diseases and ascorbic acid deficiency (Russel et al. 1968; Pelletier, 1968; Brook and Grimshaw, 1968; Bailey et al. 1970). Bourquin and Musmanno (1953) confirmed by in vitro tests that nicotine in amount roughly equal to that which might be absorbed by a heavy smoker, actually destroyed ascorbic acid in solution. They also reported that the level of ascorbic acid in the blood was reduced by smoking. The in vitro test has also been confirmed by Calder et al. (1963), but they were unable to show that the plasma level was reduced in smokers or non-smokers who smoked one cigarette every half hour over a period of 6 hours or in smokers who smoked 19-25 cigarettes in 6 hours. Bailey et al. (1970), have found no difference in the response of smokers and non-smokers in relation to ascorbic acid supplementation and exercise performance. By saturation tests carried out in conjunction with carefully controlled dose schedules and blood measurements, Pelletier (1970) concluded that in smokers, less ascorbic acid is effectively available for utilization or that this group utilises the vitamin differently from non-smokers.

Ascorbic acid is involved in the synthesis of neurotransmitters such as noradrenalin and 5-hydroxytryptamine, and in the function of the adrenal gland. This organ contains the highest concentration of the vitamin of any tissue in the body and this must therefore have some influence on catecholamine and steroid production. Smoking is well known to induce increased adrenalin secretion via nicotinic stimulation by nicotine and hence in smokers there is probably an abnormal demand on the adrenals and an increased utilisation of ascorbic acid at this site. It is also postulated by Kitabchi (1967) that a high concentration of ascorbic acid in the adrenal prevents steroidogenesis and therefore during stress or stimulation with ACTH, the adrenal must first release the bulk of its ascorbate before stimulation can commence. The effect of smoking and adrenal function could thereby represent one consistent source of ascorbic acid depletion.

Attention has recently been drawn to the low leucocyte levels of ascorbic acid in many surgical patients (Cohen and Duncan, 1967) and particularly in patients with peptic disorders. The importance of vitamin C in the healing process has been demonstrated in guinea pigs and in humans (Wilson et al. 1974). There is also a consistently low level in patients with peptic ulcer and since

these may, by necessity, be subjected to surgery, supplementations may be of considerable importance. Cohen and Duncan (1967), found that patients with gastro-duodenal disorders had significantly lower leucocyte ascorbic acid levels than normal healthy adults. The mean levels quoted were 11.0ug/10^8 W.B.C. and 22.9ug/10^8 W.B.C. respectively.

Infections apparently decrease the amount of ascorbic acid in tissues and body fluids. Normal recommended intakes of vitamin C are thought to be helpful in enabling the body to combat infections. There is no evidence that amounts greatly in excess of normal recommended intake confer extra benefits, except after deprivation or during periods of unusual physical stress. The possibility recently suggested by Pauling (1970), that very large intakes of vitamin C can protect against the common cold, therefore is without good scientific foundation (Diehl, 1971; Hodges, 1971 and Wilson, 1971). In a study where 20 healthy subjects were exposed to cold and then given 200mg ascorbic acid daily for 17 days, it was reported that plasma ascorbic acid increased to 1.2mg/100ml compared with 0.6 to 0.7mg in the untreated group. Basal metabolic rate (BMR) increased simultaneously and it was concluded that ascorbic acid seemed to

enhance the resistance to cold by raising the body temperature and BMR (Makamura et al. 1967).

ASCORBIC ACID - SPECIAL REFERENCE TO NIGERIA

Nigeria can safely be divided into two dietary zones. The northern part of the country (consisting of parts above the rivers Niger and Benue) in which the staple diet consists of dried cereals and pulses supplemented with vegetables and the sourthern part (consisting of all parts below the Niger and Benue rivers) in which the staple diet consists of roots and tubers supplemented with lots of fresh fruits and vegetables. Fruits and vegetables are the main source of ascorbic acid in the Nigerian diet although some is also contributed by liver and dried milk.

Taylor et al. (1975), reported on the ascorbic acid content of some Nigerian leafy vegetables as affected by age and nitrogen fertilization. The mean ascorbic acid content (mg/100g edible portion) of "tete" (Amaranthus Candatus), pumpkin (Curcubita pepo) and Isoko (Telfaria occidentali) were 36.5, 42.4, 85.5 and 61.5, 27.2, 23.5, 17.5, 6.6 and 178.7, 178.1, 191.4 and 226.7 at 5, 7, 9 and 11 weeks respectively. Nitrogen fertilization did

not significantly improve the ascorbic acid yield. The results indicate a higher content of ascorbic acid in Telfaria compared to Amaranthus which also had higher content than in Cucurbita.

Variety of fruit or vegetable is sometimes but not always, an important factor in determining the amount of ascorbic acid in the tissue, and manurial conditions, climate and seasonal variation may all be influencing factors. In a recent research at Ibadan, Oyo State, variation in ascorbic acid content in six orange varieties grown in Nigeria was studied (Ogunmodede, 1975). In all varieties, the ascorbic acid content of the oranges increased gradually from the beginning of November till middle of December. Four varieties namely Agege, Meran, Person Brown and Tangerine tended to maintain the vitamin level till the end of January. This study also showed that peeled oranges had more ascorbic acid than the juice thus indicating the presence of additional vitamin C in the endocarp of oranges and therefore the need to encourage eating the endocarp. The significance and implication of this study is partly in revealing the best time of harvesting these varieties. The Agege, Meran, Person-Brown and Tangerin should be harvested seven months after flowering while Umudike and Etinan varieties should be harvested six months after

flowering in order to obtain the maximum level of vitamin C in the fruits. Nicol (1958), investigated the ascorbic acid contents of some foodstuffs and concluded that the starchy roots and sylvan produce used by Nigerian tribes supply sufficient ascorbic acid to prevent the occurrence of clinical scurvy. In general the ascorbic acid content of the vegetables most commonly consumed in Nigeria ranges from 18-98mg per 100mg of the fresh material (Oke, 1967). In another study Reiff (1959) reported that fresh citrus fruits contained 40-100mg ascorbic acid per 100 grams, and that locally canned fruit juices may form an adequate substitute in days of scarcity of the fresh fruits since they are also adequate in ascorbic acid.

The value of any foodstuff as a source of vitamin C depends on how much of the ascorbic acid is available at the time of consumption. It is therefore necessary to investigate the effect of traditional methods of preparation on the ascorbic acid value of foodstuffs. In Nigeria the most popular method of cooking vegetable is boiling. Nicol (1956), observed that vegetable leaves and fresh pepers when boiled in an emulsion of oil and water lose on an average 67% of the ascorbic acid present in the edible portion. Oke (1966a), showed that when liver, spleen,

kidney, lungs and heart of beef cattle are boiled for ten minutes, losses of ascorbic acid content approximated 52%. Most Nigerian vegetables in the raw state are rich sources of ascorbic acid but on boiling 46–68% of the ascorbic acid is lost (Oke, 1967).

The production of fruits and vegetables is very seasonal in Nigeria and this fluctuates with season of plenty (rainy season) and seasons of scarcity (dry season). There is usually a high demand for off season supply of fruits and vegetables which means in essence that adequate preservative methods must be provided. Processing and storage provide a considerable improvement on the shelf life of food but is sometimes accompanied by nutrient loss. Oke (1966b) observed that root products such as cassava flour (gari, fufu, lafu) and yam flour obtained by fermenting, sun-drying and grinding still contain an appreciable amount of ascorbic acid.

The general belief is that because fruit and vegetables are abundant in southern Nigeria, scurvy does not exist among the general population. Certainly its appearance is hardly seen in adult Nigerians, but there is a widespread peridental disease which works the teeth of middle aged people loose, and provides pockets of pathogenic bacteria in the mouth (Bassir, 1965).

Among weanling children in western Nigeria a mild scurvy is well known as "yoro" in Yoruba. Recently Edozien et al. (1960) undertook a survey of the incidence of this disease among children and discovered some classical cases which responded to vitamin C therapy. In an investigation, Reilf (1959) reported that urine and plasma vitamin C levels of 20 adult Nigerians were 0.3-3.5mg/100mls and 0.37-0.75mg/100mls respectively which showed an adequate intake of vitamin C. On the other hand Nicol (1956) in the northern States of Nigeria reported that lack of fresh fruits and leaves all year round resulted in varying degrees of dietary deficiency of ascorbic acid.

CHAPTER II

SEASONAL AVAILABILITY OF DIETARY ASCORBIC ACID IN SOME SELECTED RURAL AND URBAN HOUSEHOLDS IN ZARIA DISTRICT

INTRODUCTION

Although studies on food supplies for African communities did not begin until a few decades ago (Worthington, 1936), there is now a growing recognition of the potentially disastrous consequences of food shortages and poor dietary habits in Africa. In Nigeria, a number of nutritional surveys has been carried out (Nicol, 1956; Osifo, 1970; Ogbeide, 1974; Collis *et al.*, 1962, 1967; ICNND, 1967). The scope of these surveys has largely been limited to the examination of nutritive value of food items eaten in different parts of the country and the effects of hunger and malnutrition on the health of the population. No attempts have been made to relate nutrient deficiencies to the seasonal availability of food crops.

In a dietary survey conducted among children in Kaduna, attention was drawn to the seasonal variation in the diet. The caloric value of the diet was lowest at the end of the dry season in March and highest in September. Similarly the intake of protein was lowest in June and highest in September being largely dependent upon the amounts of cowpeas, yams, beef and dried fish eaten. The amount of ascorbic acid supplied by the diet was found to be highest in June during the mango season

and lowest in March. In the same study some clinical symptoms of nutritional deficiency such as gingivitis, follicular hyperkeratosis and angular stomatitis were reported in children aged 4 to 6 years and 10 to 12 years between the harvest and planting seasons (Nicol, 1956, Chartres, 1951). A higher incidence of poor nutrition and thinness was found among school girls during the late dry season in Northern Nigeria. Seasonal deficiency of ascorbic acid was also suggested especially among people of Hausa tribe afflicted with the red, swollen and bleeding gums (Wilson, 1954).

A study of the diet of 12-year-old children of Ibo and Yoruba salaried officials living in Kaduna, revealed that the diet supplied inadequate amount of ascorbic acid (Nicol, 1958). According to the same survey, intake of fresh fruits and vegetables was generally low during ten months of the year except from mid April to mid June when mangoes are in season.

In the last two decades, there has been increased variety of food available to the consumer through better methods of farming and importation of foodstuffs to supplement local production. It is also undoubted that there has been general improvement of the food/habits of most Nigerians thereby resulting in better health and nutrition. It is therefore necessary to

follow up the dietary patterns of Nigerians to ascertain the extent of this improvement.

Children aged two to four years are just being introduced to the adult diet and have been reported not to have a liking for vegetables (Wilson et al., 1974). Since vegetables constitute the largest source of ascorbic acid, it is necessary to examine the diet of this age group to ascertain whether their low intake of vegetables provide an adequate dietary ascorbic acid. The replacement of milk teeth normally occurs between the ages of five to seven and because ascorbic acid has been found necessary for dentine formation (Marks, 1968), it is desirable that the diet of this age group be adequate in ascorbic acid. Many reports (Andrews and Brook, 1966; Griffiths et al., 1966; Brocklehurst et al., 1968), have indicated low intake of ascorbic acid in the elderly but no such evidence has been observed in Nigeria.

The present study was therefore to investigate the food consumption habit of some selected Nigerian households living in rural, sub-urban and urban locations of Zaria district, and establish seasonal variation in ascorbic acid intake of subjects of different age groups.

MATERIALS AND METHODS

Selection of Sample Households

Survey locations for the food consumption studies were selected in and around the Zaria town. Twelve locations were studied, these were five rural villages (Bomo, Hunkuyi, Basawa, Zangon-Aya and Shika), four sub-urban locations (Samaru, Palladan, Jema'a and Wusasa) and three urban locations (Sabon Gari, Tudun Wada, and Zaria City) (Fig. 1). Contacts with the selected families were made through the village heads and Home Economics Extension workers, who had been working with the families in other types of surveys.

Families were chosen from as wide sample of the population as possible to include variations in occupation, socio-economic level, tribal or cultural background, size of the family. A total of one hundred and thirty families were surveyed in the twelve locations representing a total population of one thousand and twelve subjects (Table 1).

Background information

Background information was obtained from all survey locations

between October and November, 1976. Information sought included types of food available, planting and harvesting periods and marketing patterns of crops commonly found in the locations at different seasons of the year.

Food Consumption Survey

The food consumption survey conducted between October 1977 and September, 1978 was planned to include one full year for the obvious reasons of seasonality. The survey year was divided into two six-month periods; - October to March which corresponds to the dry season and April to September, the wet season. The survey included weighing of food consumed recording dietary intake and obtaining further information on socio-economic status, food supply, food preservation and meal patterns using a questionnaire for literate respondents and conducting an interview to obtain the same information from illiterate respondents. A pilot study was conducted using the questionnaire. As a result of the pilot study, it became necessary to modify and reduce the length of the questionnaire. A detailed dietary survey was conducted using 102 subjects during December 1977 and January 1978 corresponding to the

middle of the dry season. During June and July 1978, a second set of dietary study was conducted in the same families to obtain information for ascorbic acid intake during the rainy season. Food consumption was determined during a consecutive five day period following a two-day preliminary period.

Interview Schedule

Each household was interviewed three times during the dry and again during the rainy seasons. The interview schedule is shown below:

Season	Stage	Months	Interview
	Beginning	October to November	1st
Dry	Middle	December to January	2nd
	End	February to March	3rd
	Beginning	April to May	1st
Rainy	Middle	June to July	2nd
	End	August to September	3rd

Collection and Analysis of Food Samples

Samples of raw and cooked food consumed by the respondents were collected in separate plastic wide mouth jars with covers and transported to the laboratory under normal atmospheric temperature. Ascorbic acid determinations were carried out immediately on arrival in the laboratory on the same day of collection or when not possible were refrigerated at $4^{o}C$ for a maximum of 48 hours.

The phenyl-hydrazine method of Schaffert and Kingsley (1955) was used for colourless foods while the bromosucciniamide method of Evered (1960) was used for highly coloured foods. It was observed that the Schaffert and Kingsley (1955) method was unsuitable for highly coloured foods since they contain pigments which absorb light at about the same wavelength as does 2; 4 dinitrophenyl-hydrazine. This interfers with ascorbic acid determination because the osazones produced could not be read on the spectrophotometer. However, the titrimetric method of Evered (1960) using N-bromosuccinimide was found suitable for the coloured foods.

Determination of total ascorbic acid by phenyl-hydrazine method (Schaffert and Kingsley, 1955).

Reagents

1. Ascorbic acid (BDH)

   Standard solution was prepared by dissolving 100mg of ascorbic acid in 4% (w/v) trichloroacetic acid made to a volume of 100ml. Two ml of this stock standard solution was diluted with 4% trichloroacetic acid to 100ml. One ml of this solution contained 20ug of ascorbic acid.

2. Trichloroacetic acid 4% (w/v) aqueous solution.

3. Activated charcoal (Norit).

4. Thiourea: 10gm thiourea (BDH) was dissolved in 50ml of ethyl alcohol and diluted to 100ml with distilled water.

5. 2, 4 dinitrophenyl-hydrazine 2g of 2, 4-dinitrophenyl-hydrazine (BDH) were dissolved in 100ml of 9N sulphuric acid. It was left overnight and filtered through Whatman No. 42 Filter Paper.

6. 85% sulphuric acid (R.G) 900ml of concentrated sulphuric acid was added to 100ml of water.

7. Oxalic acid 0.5% (w/v) aqueous solution.

Procedure

Twenty five ml of the working standard was shaken vigorously with half teaspoon of charcoal for one minute in an Erlenmeyer

flask. The mixture was filtered through a Whatman No. 42 filter paper. Aliquots of 0.0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0ml of the filtrate were taken into seven test tubes and volume made to 4ml with 4% trichloroacetic acid. One drop of thiourea and one ml of 2, 4 dinitrophenyl-hydrazine were added and the tubes incubated for ten minutes in a water bath preheated to 100°C. The tubes were cooled in crushed ice. Five ml of 85% sulphuric acid were added dropwise to each tube, mixed and allowed to stand for ten minutes. The transmittance of these colours formed were read at 515mm in a spectrophotometer*. A standard curve of absorbance versus concentration of ascorbic acid was drawn (Fig. 7).

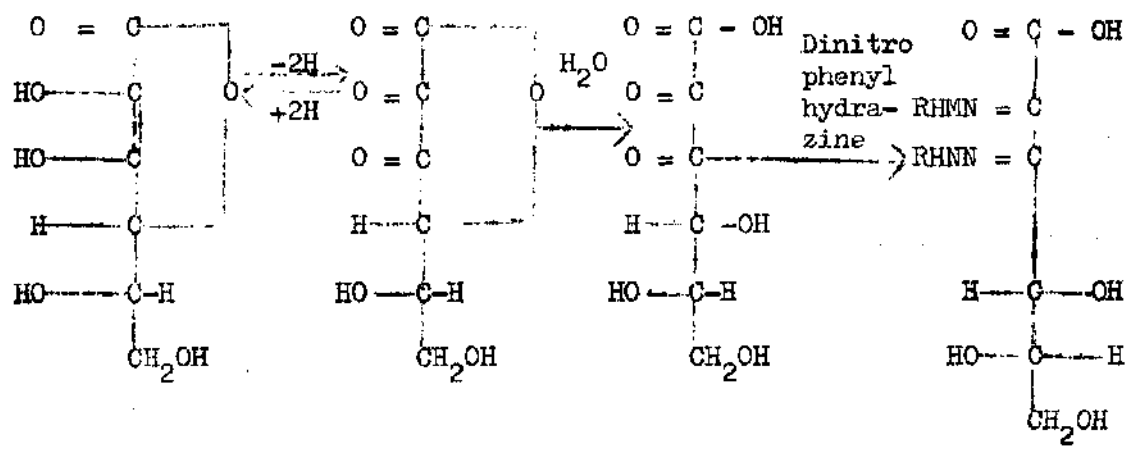
Four gram portion of the food sample was weighed into a waring blender containing 96ml of 0.5% oxalic acid and was pulverised for ten minutes and filtered through a Whatman No. 42 filter paper. To 20ml of the filtrate, half teaspoon activated charcoal (Norit) was added and shaken vigorously for one minute. The extract was filtered again through a Whatman No. 42 filter paper.

Four ml aliquot of the filtrate was treated exactly as in case of standard solution described above. Triplicate determina-

---

* Bausch and Lomb Spectronic 20.

tions were made for each food sample. Ascorbic acid content was evaluated from the absorbance with reference to the standard curve. The reaction is shown below:



Bis-2, 4 dinitro-phenyl-hydrazone

Determination of ascorbic acid by N-bromosuccinaimide (Evered, 1960).

Reagents

1. A stock solution of N-bromosuccinaimide (BDH) was prepared by dissolving 200mg of the crystals in warm water, cooling and diluting to 100ml. This solution was stable for two days in refrigerator. Just before use, the stock solution was diluted 10 times with water. One ml of the diluted solution was equivalent to 20ug ascorbic acid.

2. Glacial acetic acid.
3. Potassium iodide 4% (w/v) aqeous solution.
4. Diethylether.
5. Ascorbic acid (BDH)

   Standard solution was prepared fresh each day by dissoving 20mg of ascorbic acid crystals in 1% (v/v) acetic acid and made to a volume of 100ml.

Procedure

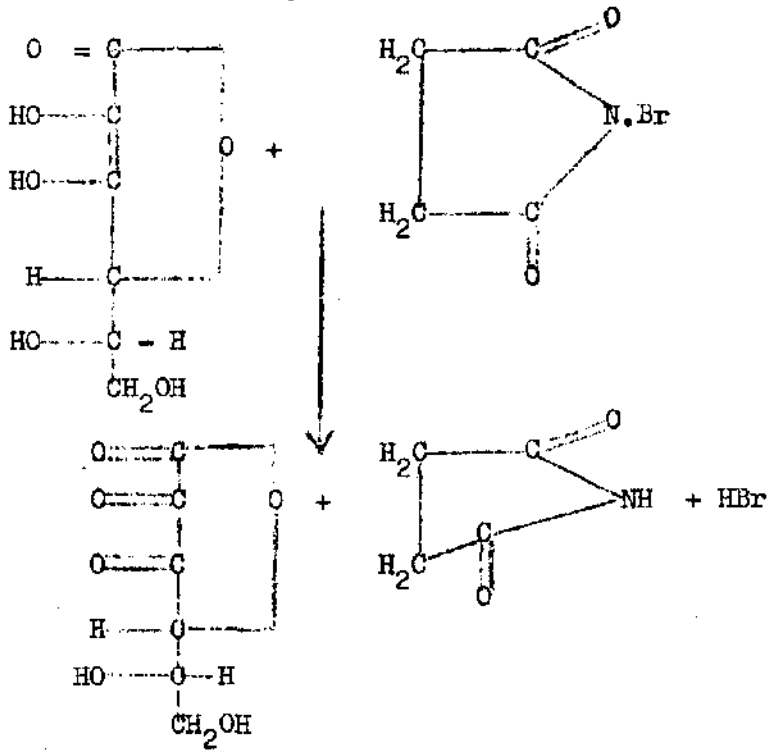
Ten grams of the solid food sample was thoroughly blended and transferred to a 100ml volumetric flask with 1% V/V acetic acid diluted to mark with the same reagent. The mixture was then filtered through a Whatman No. 42 filter paper. For highly viscous mixtures, filtration was done under sunction using Buchner apparatus. In case of fluid samples, 50ml of the sample was transferred into a 100ml volumetric flask and diluted to mark with 2% acetic acid. The mixture was then filtered through a Whatman No. 42 filter paper.

Five ml portion of the extract was transferred to a 25 x 100 mm test tube, one ml of glacial acetic acid and 5ml of potassium iodide solutions were added and mixed thoroughly. Three ml of diethyl-ether were added to form an immiscible upper layer. The

contents of the test tube were then titrated with N-bromo-succinaimide solution. The tube was shaken after each addition of the titrant and was allowed to settle until the upper layer separated.

The end point was indicated by the first appearance of brown colour of liberated iodine in the upper layer. A blank titration was carried out using 5ml of water to replace the diluted sample extract. The blank titration indicated the volume of N-bromo-succinaimide solution necessary to impart a definite colour to the diethyl-ether layer. The N-bromosuccinaimide solution was standardised suing the same procedure but titrated against 5ml aliquots of the standard ascorbic acid solution.

The reaction proceeds quantitatively in equimolar concentrations according to the equation:



Statistical Analysis

Significance of the difference between the means for ascorbic acid intake within each age group in all locations during the two seasons was tested by student's t-test as described by Snedecor and Cochran (1971).

RESULTS

Socio-Economic Characteristics of Families included in the Food Consumption Survery

Families which participated in the food consumption survey were from different ethnic groups, Hausas being predominant (Table 2). The Hausas, Fulanis, Kajes and Jabas are the normal inhabitants of Zaria area while the other ethnic groups are immigrants. These immigrants included in this study have had a minimum of ten years residence in Zaria area.

Average family size was 7.8 persons. About two-fifth of the families had thirteen to twenty members in each and another third had twenty or more (Table 3). These are characteristics of Nigerian society and the persons living in the same household usually comprised of man, his wife/wives, children and other relatives.

In this study particular attention was paid to the education of heads of families, the wives and other people connected with food preparation since it is thought that the level of education might influence food selection as well as cooking procedure. It was observed that a large percentage of respondents from the rural households have no formal education. Scattered within the sub-urban and urban population are respondents with various levels of education ranging from adult literacy training to University education. Closely related to the level of education is the occupation of respondents.

The main occupation of rural men in dry and rainy seasons is farming. Other main occupations observed include tailoring, bricklayering, trading and teaching (Table 4). In addition to their main occupation one-third of the men have part-time jobs to supplement their income. All women with the exception of the old ones interviewed, were responsible for cooking. In addition to household responsibilities, most of the women have some form of income generating activity which they do at home. Such activities include food preparation and selling, pounding grains for other women, cap-making and mat-making.

In the sub-urban locations, occupational patterns of respondents varied from craftmanship, farming to wage earning,

but majority of the respondents were employed by the Ahmadu Bello University (Table 5). In addition to their regular occupation about 75 per cent of the respondents indicated that they do some gardening and livestock keeping around their houses in response to the Operation Feed the Nation Campaign. In contrast to the respondents in the rural areas only two people reported having part-time jobs to supplement their income. Some women in Palladan and Jema'a where the Muslims predominate were in purdah and their occupational patterns relate closely to their counterparts in the rural areas. In Samaru and Wusasa where there is a preponderance of Christians or immigrants, eighty five per cent of the women had jobs outside their homes and this ranged from trading to University administration.

Occupation of urban male respondents ranged from farming, wage earning to trading (Table 6). Thirty six per cent of the female respondents had jobs outside their homes. Most women interviewed in Zaria City and Tudun Wada which are predominantly Muslim areas were in purdah and therefore engaged in jobs which could be done within their homes such as cap weaving or and pounding grains for other women.

Food Supply

The results of the farm survey indicate that most crops are seasonal and they are planted at the beginning of the rainy season that is in May and harvest season starts from August and may extend till November depending on the maturity of the crops. However, farmers in riverine areas produced vegetables such as spinach, okro, peppers, tomatoes all year round because of the availability of water from nearby streams. It was also observed that the appearance of most food crops in the market correspond with the harvest time and may last as long as five months. Owing to non-availability of good processing and storage facilities most of the fresh foodstuffs are available in the market for a few months after the start of harvest. Table 7 shows planting and harvesting time of crops grown. In addition to food crops grown on farms around Zaria area, in the market are other foods such as citrus fruits, pineapple, bananas which are imported from neighbouring States. The rainy season is usually characterised by an abundance of fresh fruits and vegetables, but as soon as the dry season sets in, less of the fresh vegetables are available, rather there is a lot of dried vegetables. There are certain fruits which are available in the market during the

dry season only, some of which are mangoes, sugar cane, carrots and garden eggs. The consumption of these fruits contribute to the ascorbic acid intake of the residents of Zaria during the dry season. During the period of this survey it was observed that fresh vegetables were more abundant in the market than the previous two years probably due to a longer rainy season.

During the food consumption survey, respondents were asked to indicate the source of the foodstuff they consumed. This survey shows that within the rural population, 85% of the respondents produce most of the foods they consumed which included guinea corn, millet, maize, beans, spinach, onions, garden egg, carrots, sweet potatoes and yams. However, during the dry season most households have to buy some fresh vegetables to supplement the dry ones preserved. Ninety five per cent of the households visited had in or around the compound a baobab tree which is a source of baobab leaves called "Kuka". Both the fresh and dried leaves are used in soup making.

In the sub-urban location, the pattern of food supply deviated from that observed within the rural population. Most foodstuffs are obtained from the market since 84% of the

respondents are non-farmers. However, during the rainy season a lot of backyard farming is done where vegetables such as tomatoes, spinach, garden eggs and peppers are produced. The pattern of food consumption varied from that observed in the rural areas because of the variety of ethnic groups that inhabit the sub-urban areas. Foodstuffs eaten include yams, groundnuts, rice and leafy vegetables. Only three houses in Samaru had Baobab tree, all other households which consume "Kuka" obtained it from the market. The consumption of some commercially produced foodstuffs was observed within the sub-urban households, such as orange drinks.

Except for the farmers in Zaria City the urban respondents obtain their food from the markets. Due to the congestion characteristic of urban areas respondents from Sabon-Gari and Tudun Wada do not practice any backyard gardening and therefore rely on the market for their supply of vegetable throughout the year.

Seasonal Food Consumption

Dry Season: Foodstuffs eaten during these period are sweet potatoes, yams, rice, groundnuts, millet, guinea corn, maize.

The Hausas and Fulanis in all the three survey locations consumed a lot of sweet potatoes while the Tivs, Idomas, Yorubas and Kajes consumed a lot of yams. Between November and December sugar cane is harvested and the consumption of this foodstuff was prominent in all the survey locations. Vegetables consumed during the dry season are spinach, sorrell leaves, baobab leaves, okro, kalkashi, bitter-leaf, water leaf, tomatoes and red peppers. Within the rural population 86% of the households used mainly dried baobab leaves, dried okro, kalkashi and peppers during the dry season while 47% mixed the dried vegetables with some fresh ones usually in the ratio of 3:1. Such mixing of vegetables was also observed among the sub-urban populations but the proportion of people using such a mixture was considerably less. As a result of dry season farming such vegetables as okro, spinach, sorrell leaves, kalkashi, peppers were available fresh in the market during the dry season but they were much more expensive than they normally were during the rainy season. Because of this very few people could afford the fresh vegetables.

The consumption of fruits such as oranges, pawpaw, pine-apple was not significant in all the survey locations probably due to their high cost since they are mostly imported from the souther States. It was however, observed that 10-12% of the

sample population within the sub-urban and urban locations consumed manufactured fruit drinks which is a source of ascorbic acid. This is in agreement with the findings of Reiff (1959). Between January and February carrots and garden eggs are harvested. These fruits were eaten as snacks in all the households interviewed and they may contribute significant source of ascorbic acid to the diet. As the dry season draws to an end in the month of April, mangoes become ripened and are consumed by all households within the three survey locations.

It was observed that during the dry season a cooling beverage "Kunun Zaki" made from fermented guinea corn was consumed by more than 70% of the sample households.

Rainy Season: Foodstuffs consumed during the wet season do not differ significantly from those eaten during the dry season except that they are fresh. Vegetables such as spinach, bitterleaf, baobab leaves, sorrell leaves, water leaf and peppers are available in abundance, they are cheaper and are eaten more regularly. The ascorbic acid content of these foodstuffs are shown in Table 8-13.

FOOD PREPARATION

In all the survey locations, the task of food preparation was found to be that of the wife/wives in the different families. Sometimes the grown up girls in the homes do help in food preparation. In the rural households three meals are cooked everyday probably due to the fact that the women do not have any occupation outside their homes. The respondents in the rural locations use mostly methods of boiling and stewing for food preparation. Occasionally they fry foods such as potatoes.

Because of large fraction of the sub-urban respondents are wage earners, two or three meals are cooked everyday. However, the method of food preparation do not differ significantly from the rural respondents.

In the urban locations, two to three meals were cooked everyday. Those whose jobs take them out of their homes for most of the day ate the afternoon meals away from home. The effect of the different methods of food preparation on ascorbic acid retention will be discussed in chapter five.

MEAL ANALYSIS

Morning Meals

The pattern of consumption of various food items at the morning meal shows considerable variation in the survey locations.

Rural

The favourite foods for the morning meals were either "Koko" or "Kunu" and "Kosai" or left-overs of "Tuwo" and "Miya". In most cases "Koko" or "Kosai" was purchased commercially. Eighty five to ninety per cent of the families reported this type of morning meals. It was observed that during the rainy season the consumption of "Kosai" dropped probably due to the high cost of beans. The consumption of freshly made tuwo was reported in 5% of the households. Five to ten per cent reported the consumption of tea and bread.

In the rural locations morning meals were taken quite early usually between 7.30 a.m. and 8.00 a.m. However, in three household in Bomo and Shika, it was observed that morning meals were eaten much later. This was so because some of the children attended the nearby primary schools and they usually had a break at 9.00 a.m. to come home for breakfast.

Food analysis, showed that families which ate "Koko", "Kunu" and"Kosai" in the morning had no ascorbic acid in their morning meals while those who ate left-over or newly made "Tuwo" and "Miya" had between 5 and 10mgs.

Sub-urban

The Hausas and Fulanis resident in the sub-urban areas reported taking "Koko", "Kunu" and "Kosai" in the mornings. The favourite foods for the other tribes within the sub-urban locations are tea and bread or yam and stew. In about five per cent of the families whose main occupation is farming "Tuwo" and "Miya" are common morning meals. It was observed that yam and stew and "Miya" contributed to the ascorbic acid intake of the respondents.

Urban

Seventy-five per cent of the farmers of Tudun-Wada and Zaria City reported eating "Tuwo" and "Miya" as morning meals while the other 25% reported eating "Koko", "Kunu" and "Kosai". Eighty per cent of the traders reported drinking tea and eating bread while the other 20% did not have morning meals. Among the non-Hausas living in the urban locations, the consumption

of tea and bread was reported as the most favourite morning meal.

Mid-day Meals

The main mid-day meal reported by respondents in the rural areas included yam pottage with vegetables, guinea-corn pottage, "Fura" and "Nono", "Tuwo" rice and vegetable soup; yam and stew, sweet potatoes and stew, semovita and vegetable soup. During the rainy season it was observed that 90% of the families ate pottage and vegetable soup due to the abundance of fresh vegetables at this time. On the other hand during the dry season 95% of the families preferred fura and nono due to its cooling effect. About 58% of the families ate commercially prepared "Fura" and "Nono" while others made theirs in their homes.

Of the rural men, 3.4% are full time traders who had their mid-day meal away from home. Such meals usually consisted of "Fura" and "Nono" or groundnut cake with some form of leaves "Rama" or "Zogale".

Within the rural population the complete absence of cassava meals was noticed. Vegetable soups that are more commonly eaten are "Kuka", Okro, "Miyan taushe", melon/spinach, "Kalkashi" pumpkin/sorrell, rama, bitterleaf.

In the sub-urban locations, the pattern of mid-day meals varied sharply from that observed in the rural areas. Foods that are commonly eaten as mid-day meals include rice with vegetable soup, yam pottage, cassava, pounded yam. Some imported commercial foods such as macarroni, spaghetti, semovita, were reported in families where the heads were craftmen or wage earners. The farmers within the sub-urban locations were Hausas and Fulanis and their pattern of mid-day meals was similar to that reported in therural areas. Among the non-Hausa respondents of the sub-urban locations vegetable soups which are mostly consumed are spinach, melon-spinach, okro, "ayoyo" beanseed and bean soup.

The farmers respondents in the urban areas reported eating yam pottage, sweet potatoes, pottage and guinea corn during the rainy season while most of them ate "Fura" and "Nono" during the dry season since very little farming was done at that time. Seventy-five per cent of the traders reported eating commercial mid-day meals away from home while the remaining 25% carried their mid-day meals with them from home. Meals that were bought include rice and stew, yams and stew, "Alele", "tuwo" and "miya", cassava and vegetable soup, "fura" and "nono".

Evening Meals

The majority of evening meals reported by farmers in all three survey locations consisted of "Tuwo" usually made from the guinea corn, millet, maize or rice and vegetable soup. The most popular soup among the Hausa/Fulani farmers is "Kuka" which is made from baobab leaves. It was observed that this soup was consumed at least once a day since 97% of the households had Baobab trees within their homes and for others who did not have, it was always within an easy reach from a neighbour's house. Commercially prepared food items were unfrequently eaten at the evening meals.

Among the wage earners and crafts-men it was observed that in addition to cereals, various starchy roots are often consumed in the evenings. These were also eaten with vegetable soups.

Snacks

Times of eating snacks varied from one individual to another and depends more on needs rather than a pattern of eating. Such snacks eaten include kolanuts, roasted groundnuts boiled groundnuts during rainy season, groundnut cakes, or some commercially prepared foods such as biscuits, dates, popcorn,

bean cakes, "alkaki", boiled cassava. During the dry season, snacks usually included carrots, mangoes and garden eggs.

SOURCES OF ASCORBIC ACID IN THE DIET

The chief source of ascorbic acid in the diet of all the respondents is vegetables. Only 3% of the respondents in the sub-urban and urban locations reported the consumption of citrus and other fruits such as pineapple and bananas. In the rural locations dried Baobab leaves and okro both fresh and dried which are made into soup form the chief source of ascorbic acid. Other vegetables which are use mainly during the rainy season are "kalkashi", sorrell, "rama", "spinach" and"zogale". In addition to these leafy vegetables, red peppers, sweet peppers, tomatoes, hot red peppers and onions also contribute to the ascorbic acid intake. During the dry season more dried vegetables are consumed, however, between November and December sugar cane is harvested and in 100% of the rural households consumption was reported to be between 70 and 100g per day which contributed about 4 to 6mg ascorbic acid to the diet. Also during the dry season the consumption of "fura" and "nono" was reported. Consumption of

"nono" varied from 120-250 millilitres per day which contributed about 3.9 to 5.0mg ascorbic acid to the diet.

In the sub-urban and urban locations the consumption of spinach (Amaranthus candatus) was very rampant. Other vegetables which contribute to ascorbic acid intake are peppers, onions, "ayoyo", okro, sorrell leaves, bitterleaf and water leaf. The consumption of commercial fruit drinks was reported in 1.5% of the urban and sub-urban households. These fruit drinks also contribute to the daily ascorbic acid intake.

FOOD PRESERVATION

Respondents in all three survey locations reported some form of food preservation during the dry season. These preserved vegetables are used when the fresh ones are scarce during the dry season. The most popular method of vegetable preservation was drying.

Vegetables that were preserved by drying included Baobab leaves, bitterleaf, "kalkashi", "ayoyo", okro, red peppers and sweet peppers. In the urban and sub-urban locations, 8% of the respondents reported the preservation of yams as yam flour.

Those vegetables that would be dried were collected at the end of the rainy season and dried usually on the roof of houses or on open fields adjacent to the houses. Drying usually took one or more weeks or sometimes shortern than this during the harmattan. The dried vegetables are then stored in calabashes or bottles. Storage and use of these dried products ranged from 2-12 months.

DIETARY SURVEY

The distribution of subjects studied in the dietary survey is shown in Table 14. The daily ascorbic acid intake of subjects in the three age groups is presented in Tables 15, 17 and 19 respectively. Detailed daily food consumption in dry and rainy seasons is presented in Appendix 2-19.

Children, two to four years old

The mean ascorbic acid intake of all children, two to four years old, was 34.69mg/day in the dry season and 48.62mg/day in the rainy season. All the children had ascorbic acid intake higher than 15mg/day which is the Nigerian recommended allowance (Idusogie, 1971). Ascorbic acid intake was highest (54.7mg/day)

among rural children during rainy season and lowest (31.23mg/day) among sub-urban children during dry season. The high intake of ascorbic acid by the rural children could be attributed to the consumption of fresh baobab leaves which contributed to an extent of 31-34mg per day. Vegetables constitute the major source (80-88 per cent) of ascorbic acid in the diet of children, two to four years old during rainy season and (72-79 per cent) during dry season; while fruits contribute 5.68-12.60% of the nutrients in both the seasons (Table 16). Fruits which are eaten in significant amounts are garden eggs and sugar cane. Consumption of pineapple and orange drinks was reported among the urban children only.

Children, five to seven year old

The mean daily intake of ascorbic acid was higher during the rainy season (64.74mg/day) than during the dry season (46.91mg/day) (Table 17). The mean values represent a higher intake of ascorbic acid than the allowance of 20mg/day recommended for the Nigerian children (Idusogie, 1971). The sources of ascorbic acid in their diet is shown in Table 18. Vegetables contribute 77.0-85.79% during the rainy season and

63.26-73.08% during dry season. In the urban and sub-urban locations processed fruit drinks contributed 10-28% of the ascorbic acid intake. Only one subject in the urban location reported the consumption of fresh citrus fruits.

Aged People 55 to 72 years old

The ascorbic acid intake of twenty aged people 55 to 72 years old is shown in Table 19. The mean daily intake of ascorbic acid during the rainy season was higher (51.93mg/day) than in the dry season (37.89mg/day). Similarly as in other age groups, rural adults had the highest intake of ascorbic acid (75.22mg/day) during rainy season while urban adults had the least intake (33.21mg/day) during the dry season.

Although food consumption was particularly low in these adults, they still had a daily ascorbic acid intake higher than 30mg/day the recommended allowance for Nigerian adults (Idusogie, 1971). The contribution of difference sources of ascorbic acid is shown in Table 20. The main source of ascorbic acid was vegetables. No subject took any citrus fruits during the period of study. However, other fruits such as garden egg and kolanuts were consumed.

DISCUSSION

Contrary to claims (Nicol, 1956a) that there is lack of fresh fruits and vegetables all year round in Northern Nigeria, the findings of this food consumption survey revealed that within the selected population, fresh vegetables were available all year round due to dry season farming. The study reported here also shows that sorghum, millet, rice, maize, cowpeas and groundnuts which are the local staples contain little or no ascorbic acid. The vegetable soups which are served along with these staples therefore become the obvious source of ascorbic acid. An important source of ascorbic acid in the rural areas was found to be baobab leaves which can be used both dried and fresh. Other leafy vegetables which are good sources of ascorbic acid are sorrell, "Kalkashi", "rama", and "zogale". During the rainy season large consumption of fresh vegetables raised the ascorbic acid intake to a relatively high level whereas ascorbic acid intake was found to be lower in the dry season due to the use of dried vegetables. However, the consumption of dry season fruits such as sugar cane, garden eggs, carrots and mangoes increases the ascorbic acid intake to

a level almost comparable to that obtained during the rainy season. It is the impression of the author that further developments in both agriculture and food industry will eliminate seasonal fluctuations in available foodstuffs.

Furthermore in these rural areas, the Fulani who sell milk in the local markets, have discovered that an emulsion of the white pulp in baobab fruit makes an excellent and inobtrusive adulterent of milk. This custom augments the ascorbic acid content of milk and supplements the amount of the vitamin in the local diet. This milk is consumed with millet balls and is known as "fura da nono". This dish is a favourite mid-day meal among the Hausas and Fulanis and from these investigations it contributes 3.75mg% to their ascorbic acid intake. This finding offers some support to previous studies by Nicol (1956b). It is therefore imperative that efforts should be diverted at propagating baobab trees being a natural habitat of the arid zone and also a cheap source of ascorbic acid.

In the sub-urban and urban locations, the high cost of citrus fruits limits its use even though contains very high amounts of ascorbic acid. The people in these locations also use vegetables to provide ascorbic acid in their diet. In contrast

to that observed in the rural areas, only about 5% of the population of these locations, use baobab leaves while others use more spinach, okro, peppers, bitterleaf, "ayoyo" and water leaf, probably due to ethnic heterogenicity. Less seasonal fluctuations in ascorbic acid intake was observed probably due to availability of fresh vegetables in the markets all year round. However, the high cost of these vegetables during the dry season reduces their use.

There appears to be some variation in the ascorbic acid content of foodstuffs, fruits and vegetables analysed. Although the majority of the estimations were close to the mean value, there were occasional large variations and the table therefore includes the maximum and minimum values. Factors that could account for these variation are known to include genetic constitution, methods of propagation, soil and climatic conditions, irrigation and fertilization, age or maturity at time of harvest and length of storage before use (Joslyn, 1970). However, the mean values of ascorbic acid content of foodstuff and vegetables in Zaria area correspond very well with those obtained by Oke (1966b) who analysed vegetables and foodstuff produced in Ibadan area.

Unless conditions of processing of foodstuff are known, it is almost impossible to predict the ascorbic acid content of a diet merely from a knowledge of the type and quantity of food consumed. It is also imperative that such processed foods must be subjected to chemical assays. Various methods of processing, cooking and storage of vegetables in Nigeria resulted in losses ranging from 21.3 to 87.3 per cent (Chapters 5 and 6). This result indicates the importance of finding better processing and storage methods which will minimize ascorbic acid loss. However, since on the average, an adult consumes between 300-500g of vegetables daily which represents an intake of 20-35mg of ascorbic acid, it is possible that their ascorbic acid requirement would be met by consumption of vegetables only.

Although kolanuts are produced in the southern States of Nigeria, they are available in Zaria area all year round. The consumption of kolanuts among the Fulanis and Hausas in particular may average about 200g per day per person and this represents an ascorbic acid intake of 38mg.

The wide scatter in ascorbic acid intake of children two to four years old may partly be due to variations in age and activity level. Ten subjects were very active, they had a higher total food consumption and therefore a higher ascorbic

acid intake. Intake of ascorbic acid was significantly ($P < 0.05$) higher during rainy season than in the dry season for children in rural and sub-urban locations. In the rural locations, the use of fresh baobab leaf soup contributed a considerable amount of ascorbic acid (80mg/100g) to the diet during the rainy season. During the dry season however, soups are made from dried baobab leaves which contributed only 31mg/100g to the diet. Although all subjects consumed the same type of cooked vegetables most of the time, the various methods of cooking could have caused variable loss of ascorbic acid thereby resulting in varying level of ascorbic acid intake. In addition reheating of cooked food might also be partly responsible for the reduced ascorbic acid intake. The lack of citrus fruits and fruit juices was particularly noticeable among the rural children, rather a considerable portion of the ascorbic acid was provided by the native sour milk ("nono") which contains 3.14mg% ascorbic acid. It is noteworthy that "nono" contains more ascorbic acid than other milk consumed except sterilized milk, the consumption of which was very low in the population studied.

There was significant difference ($P < 0.05$) in ascorbic acid intake during the rainy season between rural and sub-urban

and rural and urban children. No such differences were found during the dry season. Although food intake remained relatively the same during both dry and wet seasons, the use of fresh vegetables during the rainy season may account for the increased dietary availability of ascorbic acid.

A seasonal difference in ascorbic acid intake was also observed in children 5 to 7 years old. This difference was significant ($P < 0.05$) between the rural and urban children. In an earlier study (Nicol, 1956b) the ascorbic acid intake of farmer's children aged four to six years was reported as 10mg/day as calculated from food composition table. The results obtained by chemical analysis of food in this study indicate that ascorbic acid might be due to the effect of increased food availability and general improvement in food habit, health and nutrition of most Nigerians compared to what they were two decades ago. In addition some of the differences between Nicol's results and that reported in this work might partly be due to ghe methods of investigation. Ascorbic acid values obtained by food composition tables tend to be considerably higher or lower than those obtained by chemical analysis of the foods in particular area which gives a more accurate information

(Joslyn, 1970). A comparison of ascorbic acid values of foods reported by Platt (1945), Food and Agriculture Organisation of the United Nations, Nutrition Division (1968) and those obtained in this study is shown below. The higher values obtained in this study compared to that of Nicol who used Platt's table could be due to variety, maturity, soil conditions or agronomic practices all of which affect ascorbic acid content of foodstuffs (Wilson et al., 1974).

A comparison of ascorbic acid values of foods using food composition tables by Platt (1945), FAO (1968) and that obtained in this study

FOODS	Ascorbic acid values (Platt, 1945)	Ascorbic acid values (FAO, 1968)	Ascorbic acid values obtained in this study
Guinea corn meal	0	0	0
Millet meal	0	0	0
Boiled yam	2	not determined	6.24
Yam flour	0	not determined	0
Cassava meal flour	0	not determined	0
Boiled rice	0	not determined	0
Boiled maize	0	not determined	0
Plantain	20	20	9.62
Banana	10	9	27.35

FOODS	Ascorbic acid values (Platt, 1945)	Ascorbic acid values (FAO, 1968)	Ascorbic acid values obtained in this study
Boiled sweet potatoes	6	not determined	10.73
Groundnuts roasted	0	0	0
Locut bean cake	57	2	170
Pumpkin	15	8	38.67
Melon seed	0	5	1.22
Mango	30	42	25.40
Kolanut	not determined	not determined	18.28
Red palm oil	0	12	0
Groundnut oil	0	not determined	0
Guava	40	326	133.01
Pawpaw	50	52	98.43
Okro soup	20	not determined	20.01
Spinach soup	6.3	not determined	8.28
Water leaf	not determined	31	19.4
Onions	15	11	28.5
Tomatoes	25	50	40.3
Beef	0	0	0
Milk (sweetened) .. (condensed)	1.01	not determined	2.27
Nono	not determined	not determined	3.75
Red peppers	45	121	78.7
Sugar cane	not determined	not determined	6.11
Baobab soup	not determined	not determined	80.48

The fluctuations in ascorbic acid intake during the dry and rainy seasons would have been most evident but for the consumption of dry season fruits such as garden egg and sugar cane, which contain a lot of ascorbic acid. These fruits are eaten raw and thereby increases the amount of ascorbic acid consumed.

The present study offers some support to earlier findings of low dietary vitamin intakes among old people at home (Exton-Smith, 1970; Milne et al., 1971; Dymock and Brocklehurst, 1973). Low intake of ascorbic acid among the aged, was presumably due to smaller quantities of food consumed. It is difficult to provide a diet with the increased amount of ascorbic acid when the energy intake is lower such as occurs with the limited physical activity of old age.

The highly significant difference ($P < 0.05$) in ascorbic acid intake of rural old people during the rainy season compared to dry season could also be attributed to the consumption of soups from fresh baobab leaves. Kolanuts which contain 19.0mg% ascorbic acid are very well liked and are chewed regularly especially by the rural adults and this contributed to the intake of ascorbic acid. On the average an adult consumes 150-200g kolanut daily.

In conclusion, the diet of children two to four years old and five to seven years old and of aged people provide adequate amount of ascorbic acid all year around in the Zaria district though intake was lower during the dry season.

The seasons selected for this study were middle of dry season and middle of wet season since these were considered to be periods when intake of ascorbic acid were the lowest and the highest respectively. It is obvious however, from the authors' monthly observation of available fruits and vegetables that the situations may not be very different early or at the peak in the season.

SUMMARY

Seasonal availability of dietary ascorbic acid was studied in some selected rural, sub-urban and urban households in Zaria district. A food consumption survey was carried out using 130 households. Information was obtained on food production and supply, methods of food preparation and preservation, type of food consumed and meal pattern. Samples of food eaten were analysed chemically for ascorbic acid content.

The results indicate that the consumption of fruits is very low and so vegetables constitute the most significant source of ascorbic acid. During the rainy season fresh vegetables are abundant and the ascorbic acid requirement is easily met, however, during the dry season, dried vegetables provide the ascorbic acid in the rural areas. In the sub-urban and urban areas some fresh vegetables are available as a result of dry season farming. These are used in conjunction with the dried vegetables to provide ascorbic acid. In all the three survey locations, the consumption of dry season fruits such as mangoes, garden egg and carrots supplements the ascorbic acid intake.

The mean ascorbic acid intake for children two to four years old was 34.69mg/day during dry season and 48.62mg/day during rainy season. Children five to seven years old had a higher ascorbic acid intake during rainy season (64.76mg/day) than during the dry season (46.91mg/day). A similar trend was also exhibited by the old people with 51.93mg/day during rainy season and 37.98mg/day during dry season. Total ascorbic acid intake was significantly (P 0.05) affected by season and location. Maximum amount of ascorbic acid (98.97mg/day) was consumed by

rural children during rainy season and the minimum (24.05mg/day) by urban old people during dry season.

The most common source of ascorbic acid in the diet was vegetable soups made from fresh and dried vegetables. It was concluded that the diet of the subjects provided adequate amount of ascorbic acid all year round with a maximum during the rainy season. Rural subjects had significantly ($P < 0.05$) higher intake of ascorbic acid owing possibly to consumption of baobab leaves.

TABLE 1

AGE AND SEX DISTRIBUTION OF RESPONDENTS IN THE FOOD CONSUMPTION SURVEY

	RURAL										SUB-URBAN								URBAN						
Location	Dome		Hunkuyi		Basawa		Shika		Zangon Aya		Samaru		Palladan		Jema'a		Wusasa		Sabon Gari		Tudun Wada		Zaria City		Total
No. of Families	10		8		10		10		9		14		11		10		10		15		11		13		130
No. of Subjects	121		65		83		104		61		56		72		70		80		112		85		113		1,012
Age group (Years)	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M F
0-1	9	8	2	1	5	4	6	10	3	2	-	4	4	-	3	2	3	5	10	7	9	5	6	3	111
2-4	5	3	4	3	5	8	6	8	6	3	1	3	6	3	2	3	2	4	6	8	7	3	10	4	113
5-7	4	2	7	2	2	3	3	12	6	3	2	1	5	3	4	3	1	4	4	6	8	2	3	7	97
8-10	6	16	5	2	3	5	6	3	5	4	1	2	4	2	3	2	6	7	7	2	5	2	3	5	108
11-13	7	4	4	3	1	5	5	3	2	1	2	3	5	1	3	4	4	6	5	3	2	2	4	5	84
14-17	4	4	3	8	3	7	6	9	2	5	2	7	4	9	2	10	6	2	4	8	4	6	2	7	128
18-35	8	14	5	7	6	13	7	12	4	7	10	8	7	13	4	10	5	10	8	13	7	10	8	12	208
36-55	4	10	2	2	5	3	3	4	5	2	4	4	4	1	4	6	5	7	7	9	4	4	4	10	113
55+	2	5	2	3	4	1	1	-	-	1	2	-	-	1	3	2	-	3	1	4	3	2	6	4	50
TOTAL	51	70	34	31	34	49	43	61	33	29	24	32	39	33	28	42	37	48	52	60	49	36	46	57	1,012

M = Male; F = Female

TABLE 2

ETHNIC GROUP OF FAMILIES INCLUDED IN THE FOOD CONSUMPTION SURVEY

Ethnic Group	Number of Families	Number of Subjects
Hausas	47	546
Fulanis	19	112
Kaje/Jaba	15	89
Tiv	8	33
Idoma	11	66
Yoruba	13	79
Kanuri	8	40
Igbo	2	17
Efik	3	14
Shuwa	4	16
TOTAL	130	1,012

TABLE 3

SIZE OF FAMILIES INCLUDED IN THE FOOD CONSUMPTION SURVEY

Number in Family	Number of Families	Per cent
4- 7	18	13.8
8-12	21	16.8
13-19	52	40.0
20 or more	39	30.0
TOTAL	130	100.0

TABLE 4

OCCUPATION OF RURAL FAMILY HEADS INCLUDED IN

THE FOOD CONSUMPTION SURVEY

Occupation	No. of Respondents	Per cent
Farming	26	55.3
Wage earning	2	4.2
Craft	5	10.6
Trading	8	17.1
Koranic teaching	3	6.5
School teaching	2	4.2
Begging	1	2.1
TOTAL	47	100.0

TABLE 5

OCCUPATION OF SUB-URBAN FAMILY HEADS INCLUDED

IN THE FOOD CONSUMPTION SURVEY

Occupation	No. of Respondents	Per cent
Trading	5	11.1
Farming	9	20.0
Craft	11	25.5
Wage earning	20	44.4
TOTAL	45	100.0

TABLE 6

OCCUPATION OF URBAN FAMILY HEADS INCLUDED IN

THE FOOD CONSUMPTION SURVEY

Occupation	No. of Respondents	Per cent
Farming	14	35.9
Wage earning	8	20.5
Trading	17	43.6
TOTAL	39	100

TABLE 7

TIME OF PLANTING AND HARVESTING OF CROPS GROWN AROUND ZARIA

Crop			
Local Name	Botanical Name	Planting Time	Harvest Time
Guinea corn	Sorghum spp	June	November/December
Millet	Pennisetum typhoidean	May	August/September
Maize	Zea mays	May/June	August/September
Sugar cane	Saccharum officinale	November/December	November/December of following year
Sweet potatoes	Ipomea batatas	1st crop - June, 2nd crop - July	October/November
Cassava	Manihot utillisima	April	April of following year
Groundnuts	Arachis hypogea	April/May	August
Onions	Allium spp	Late April	August/September
Yams	Discorea spp	April	September/October
Pumpkin	Curcubita bepo	April	October
Beans	Vigna unguiculata	July	November/December
Cocoyam	Colocasia esculentum	April	August/September
Okro*	Hibiscus esculentum	April/May	June/July
Peppers*	Capsicum spp	May	August
Sorrell*	Hibiscus sabdarrifa	July	August
Tomatoes*	Lycopersium esculentum	April	June/July
Spinach*	Amaranthus candatus	April	June
Kalkashi*	Ceratotheca sesamoides	April	June/July
Ayoyo*	Circhorus olitorium	April	June/July

* Also planted in the dry season by irrigation farming around the riverine areas.

TABLE 8

ASCORBIC ACID CONTENTS OF RAW EDIBLE PORTIONS OF FOODSTUFF CONSUMED BY RESPONDENTS INCLUDED IN THE FOOD CONSUMPTION SURVEY

F O O D S T U F F		ASCORBIC ACID CONTENT (mg/100g fresh weight)	
Local Name	Botanical Name	Range	Mean ± S. D.
Maize	Zea mays	6.25 - 49.80	16.25 ± 2.72
Guinea corn	Sorghum spp	11.68 - 21.60	16.32 ± 0.84
Millet	Pennisetum typhoidean	0.50 - 1.86	1.15 ± 0.21
Rice	Oryza sativa	not detectable	0
Yam (fresh)	Discorea spp	13.75 - 20.00	17.56 ± 0.61
Yam flour	Discorea spp	9.45 - 16.00	12.25 ± 0.67
Cassava	Manihot utillisima	27.30 - 34.71	30.39 ± 0.42
Sweet potatoes	Ipomea batates	23.21 - 37.00	31.01 ± 0.94
Cocoyam	Colocasia esculentum	27.00 - 33.10	29.21 ± 0.50
Onions	Allium sp.	26.72 - 43.00	34.90 ± 0.87
Cowpeas	Vigna unguiculata	not detectable	0
Groundnuts	Arachis hypogea	not detectable	0
Soyabeans*	Glycine max	not detectable	0
Bambara nuts	Voadiizia subterranea	not detectable	0
Kolanut*	Cola acuminata	15.94 - 20.01	18.28 ± 1.23
Melon seed	Citrulus vulgaris	0.91 - 3.12	1.22 ± 0.54

* Not produced in Zaria area; imported from Plateau and Southern States.

TABLE 9

ASCORBIC ACID CONTENTS OF FRUITS CONSUMED BY RESPONDENTS INCLUDED IN THE FOOD CONSUMPTION SURVEY

F R U I T S		ASCORBIC ACID CONTENT (mg/100g fresh weight)	
Local Name	Botanical Name	Range	Mean ± S. D.
Orange juice	Citrus senensis	42.01 - 71.00	57.13 ± 2.47
Tangerine	Citrus spp	30.07 - 53.60	39.98 ± 2.18
Lemon	Citrus limon	25.40 - 41.50	34.38 ± 2.71
Lime	Citrus aurantiofoloa	23.04 - 46.21	32.90 ± 2.08
Grapefruit	Citrus paradisa	52.81 - 58.00	56.90 ± 0.93
Banana	Musa sapientum	22.90 - 31.70	27.35 ± 0.48
Plantain	Musa paradisiaca	8.64 - 13.56	9.62 ± 0.62
Sugar cane*	Saccharum officinale	4.44 - 9.12	6.11 ± 0.28
Mangoes*	Mangifera indica	24.51 - 27.63	25.40 ± 0.28
Pumpkin*	Curcubita pepo	31.04 - 47.65	38.67 ± 1.02
Pineapple	Ananas cosmosus	24.60 - 27.83	25.40 ± 0.27
Garden egg*	Solanum melongeana	4.92 - 9.37	5.30 ± 0.59
"Yalo"*	Solanum melongeana	20.45 - 26.80	22.89 ± 2.89
Guava*	Psidium guajava	130.41 -137.68	133.01 ± 0.67
Carrots*	Dauca carota	29.56 - 33.14	30.85 ± 0.49

* Fruits grown in Zaria districts.

Others imported from the Souther States.

...NHIM LIBR...

TABLE 10

ASCORBIC ACID CONTENTS OF VEGETABLES CONSUMED BY RESPONDENTS INCLUDED IN THE FOOD CONSUMPTION SURVEY

V E G E T A B L E S		ASCORBIC ACID CONTENT (mg/100g fresh weight)	
Local Name	Botanical Name	Range	Mean ± S. D.
Spinach	Amaranthus candatus	50.7 - 62.8	59.92 ± 1.03
Bitterleaf	Vernonia amygalina	48.0 - 64.0	58.80 ± 1.05
Baobab leaves	Andasonia digitata	75.2 - 98.4	88.6 ± 0.84
Sorrell leaves	Hibiscus sabdarrifa	40.6 - 67.0	49.03 ± 1.47
"Kalkashi"	Ceratotheca sesamoides	35.4 - 49.1	43.2 ± 1.15
"Ayoyo"	Corchorus olitorium	39.3 - 43.4	40.6 ± 0.98
Tomatoes	Lycopersium esculentum	31.7 - 75.0	49.5 ± 2.01
Sweet peppers	Capsicum annum	129.8 - 140.0	134.3 ± 1.29
Red peppers	Capsicum spp.	142.5 - 158.7	149.1 ± 1.07
Hot red peppers	Capsicum fructeranse	58.8 - 70.2	62.3 ± 0.70
Water leaf	Talinum triangulare	34.7 - 43.7	38.6 ± 0.87
"Soko"	Celosia argentia	40.1 - 59.3	46.2 ± 0.68
Okro	Hibiscus esculentum	43.4 - 56.8	47.6 ± 0.72
"Rama"	Hibiscus cannabinus	48.2 - 60.9	52.6 ± 3.84
"Zogala"	Moringa pterygosperma	94.7 - 109.4	102.3 ± 4.27

TABLE 11

ASCORBIC ACID CONTENTS OF BEVERAGES CONSUMED BY RESPONDENTS INCLUDED IN THE FOOD CONSUMPTION SURVEY

BEVERAGES	ASCORBIC ACID CONTENT (mg/100g fresh weight)	
	Range	Mean ± S. D.
"Nono"	3.07 - 5.21	3.61 ± 0.82
"Burukutu"	1.94 - 3.40	2.54 ± 0.88
"Kunun zaki"	11.64 - 14.34	12.54 ± 1.07
Evaporated milk[1]	2.00 - 2.48	2.23 ± 0.18
Condensed milk[2]	2.01 - 2.62	2.27 ± 0.24
Ovaltine[3]	not detectable	
Pasteurized milk[4]	1.82 - 2.50	2.00 ± 0.25
Sterilized milk[5]	13.40 - 13.71	13.56 ± 0.28
Cocoa[6]	not detectable	

1. Peak brand. Prepared in Nigeria by West Africa Milk Co. (Nigeria Ltd; Ikeja, Lagos).

2. Peak brand. Prepared in Holland by Cooperative Condensfabriek Friesland W. A. Leeuwarden.

3. Manufactured by Wander Ltd; Kings Langley Herts, WD4 8LJ, England, packed in Nigeria.

4. Prepared by Department of Animal Science, Ahmadu Bello University, Zaria.

5. Nestle brand. Prepared in Denmark for Societe des products Nestle, S.A. Vevey, Switzerland.

6. Cadbury brand. Made in England by Cadbury Ltd; Bournville, Birmingham.

TABLE 12

ASCORBIC ACID CONTENTS OF READY-TO-EAT MEALS CONSUMED BY RESPONDENTS INCLUDED IN THE FOOD CONSUMPTION SURVEY

F O O D	ASCORBIC ACID CONTENT (mg/100g fresh weight)	
	Range	Mean ± S. D.
Maize boiled on the cob	not detectable	not detectable
Roasted maize	" "	" "
Maize pap and bean cake	" "	" "
Guinea corn pap and been cake	" "	" "
Fura da nono	1.24 - 6.84	3.75 ± 0.40
Boiled yam (with skin)	2.38 - 9.72	6.24 ± 0.21
Boiled yam (peeled)	2.78 - 7.02	4.36 ± 0.06
Boiled cassava & groundnut	0.23 - 0.94	0.51 ± 0.97
Boiled sweet potatoes	7.35 - 13.08	10.73 ± 0.05
Boiled cocoyam	3.87 - 10.49	7.32 ± 0.28
Bean cake	not detectable	not detectable
Roasted groundnuts	" "	" "
Boiled rama leaves & groundnuts	4.51 - 9.37	6.47 ± 1.76
Danwake	not detectable	not detectable
Tuwon dawa and kuka soup	29.64 - 40.32	30.04 ± 0.62

TABLE 13

ASCORBIC ACID CONTENTS OF VEGETABLE SOUPS CONSUMED BY RESPONDENTS INCLUDED IN THE FOOD CONSUMPTION SURVERY

S O U P	ASCORBIC ACID CONTENT (mg/100g fresh weight)			
	Soup made from fresh vegetable		Soup made from dried vegetable	
	Range	Mean±S.D.	Range	Mean±S.D.
Okro	18.24 - 33.41	20.01 ± 0.28	4.61 - 7.04	5.37 ± 0.31
"Ayoyo"	8.24 - 13.04	10.17 ± 0.43	3.01 - 6.38	4.85 ± 0.62
Spinach	5.04 - 12.34	8.28 ± 0.84	-	-
Spinach/Sorrell	8.14 - 10.87	9.76 ± 0.02	-	-
"Kalkashi"	11.34 - 14.02	12.05 ± 0.67	2.07 - 8.02	5.04 ± 0.43
Melon/Spinach	5.93 - 8.61	7.42 ± 0.42	-	-
"Kuka"	70.08 - 90.32	80.48 ± 1.45	28.17-34.34	31.42 ± 0.93
Bitterleaf/Spinach	5.17 - 14.28	9.04 ± 0.45	-	-
Pumpkin/Spinach	9.87 - 18.23	14.38 ± 1.13	-	-

TABLE 14

DISTRIBUTION OF SUBJECTS INTO AGE GROUPS IN THE DIETARY SURVEY

Age Group (years)	Location			
	Rural	Sub-urban	Urban	Total
2-4	19	14	10	43
5-7	18	8	13	39
55-72	7	4	9	20
Totals	44	26	32	102

TABLE 15

DAILY ASCORBIC ACID INTAKE OF CHILDREN AGED TWO TO FOUR YEARS AS DETERMINED BY CHEMICAL ANALYSIS OF FOOD

Location	Daily ascorbic acid intake* (mg)					
	Dry Season			Rainy Season		
	Range	Mean	S.D.	Range	Mean	S.D.
Rural	30.54-39.37	35.35	± 3.23	48.62-60.05	54.70**	± 1.65
Sub-urban	28.75-33-75	31.23	± •.74	37.80-50.40	45.93**	± 5.71
Urban	33.55-43.56	37.49	± 3.74	34.72-53.26	45.25**	± 1.76
Seasonal mean	28.75-43.56	34.69	± 2.85	34.72-60.05	48.62**	± 3.06

* 19 subjects in rural, 14 in sub-urban and 10 in urban location.

** Significant difference between rainy and dry season at 5% level.

TABLE 16

CONTRIBUTION OF ASCORBIC ACID FROM THE DIFFERENT FOOD GROUPS IN THE DIET OF CHILDREN TWO TO FOUR YEARS OLD IN THE ZARIA DISTRICT

Food Groups	Ascorbic acid (per cent of total intake					
	Rural		Sub-urban		Urban	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
Milk & milk products	9.75	18.24	1.1	7.35	3.8	9.4
Eggs, meat and fish	0	0	0	0	0	0
Cereal & Cereal products	0	0	0	0	0	0
Roots and tubers	3.74	3.34	2.90	3.72	1.4	1.7
Vegetables	80.83	71.93	88.00	79.22	88.00	76.30
Fruits	5.68	6.49	8.00	9.71	6.80	12.60
Total	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 17

DAILY ASCORBIC ACID INTAKE OF CHILDREN AGED FIVE TO SEVEN YEARS AS DETERMINED BY CHEMICAL ANALYSIS OF FOOD

Location	Daily ascorbic acid intake (mg)			
	Dry Season		Rainy Season	
	Range	Mean S.D.	Range	Mean S.D.
Rural	36.89-45.82	40.96 ± 3.60	59.68-98-97	79.11 ± 14.58**
Sub-urban	42.46-81.46	55.34 ±13.17	41.01-71.76	61.51 ± 10.97
Urban	39.26-48.94	44.45 ± 4.01	43.88-60.35	53.61 ± 5.77**
Seasonal mean	36.89-81.46	46.91 ± 6.92	41.01-98.97	64.74**±10.44

* 18 subjects in the rural, 8 in the sub-urban and 13 in the urban locations.

** Significant difference between rainy and dry season at 5% level.

TABLE 18

CONTRIBUTION OF ASCORBIC ACID FROM THE DIFFERENT FOOD GROUPS IN THE DIET OF CHILDREN FIVE TO SEVEN YEARS OLD IN THE ZARIA AREA

Food Groups	Ascorbic acid (per cent of total intake)					
	Rural		Sub-urban		Urban	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
Milk & milk products	7.68	13.65	11.27	8.51	11.14	15.49
Eggs, meat and fish	0	0	0	0	0	0
Cereal & cereal products	0	0	0	0	0	0
Roots and tubers	3.49	12.21	3.96	3.58	2.13	1.83
Vegetables	85.79	63.26	77.0	67.51	78.16	73.08
Fruits	3.04	10.88	7.77	21.99	8.57	9.60
Total	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 19

DAILY ASCORBIC ACID INTAKE OF AGED PEOPLE 55 TO 72 YEARS AS DETERMINED BY CHEMICALY ANALYSIS OF FOOD

Location	Daily ascorbic acid intake* (mg)					
	Dry Season			Rainy Season		
	Range	Mean	S.D.	Range	Mean	S.D.
Rural	37.41-50.29	44.70	± 5.76	53.96-129.61	75.22**	± 28.60
Sub-urban	22.78-54.34	35.78	±10.27	38.20-47.98	44.03	± 2.49
Urban	24.05-43.90	33.21	± 6.59	25.44-46.31	36.57	± 8.67
Seasonal mean	22.78-54.34	37.89	± 7.54	25.44-129.61	51.93**	± 13.25

* 7 subjects in the rural, 4 in sub-urban and 9 in the urban locations.

** Significant difference between rainy and dry season at 5% level.

TABLE 2●

CONTRIBUTION OF ASCORBIC ACID FROM THE DIFFERENT FOOD GROUPS IN THE DIET OF AGED PEOPLE 55 TO 72 YEARS OLD IN ZARIA AREA

Food Groups	Ascorbic acid (per cent of total intake)					
	Rural		Sub-urban		Urban	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
Milk & milk products	5.14	14.44	5.29	10.69	3.15	11.67
Eggs, meat and fish	0	●	●	●	●	0
Cereal & cereal products	0	●	●	●	0	0
Roots and tubers	1.79	2.91	4.20	4.61	6.17	5.43
Vegetables	86.31	61.61	85.●	72.97	84.55	76.44
Fruits	6.76	21.●4	5.51	12.18	6.13	6.46
Total	100.00	100.00	1●0.●0	100.00	100.00	100.00

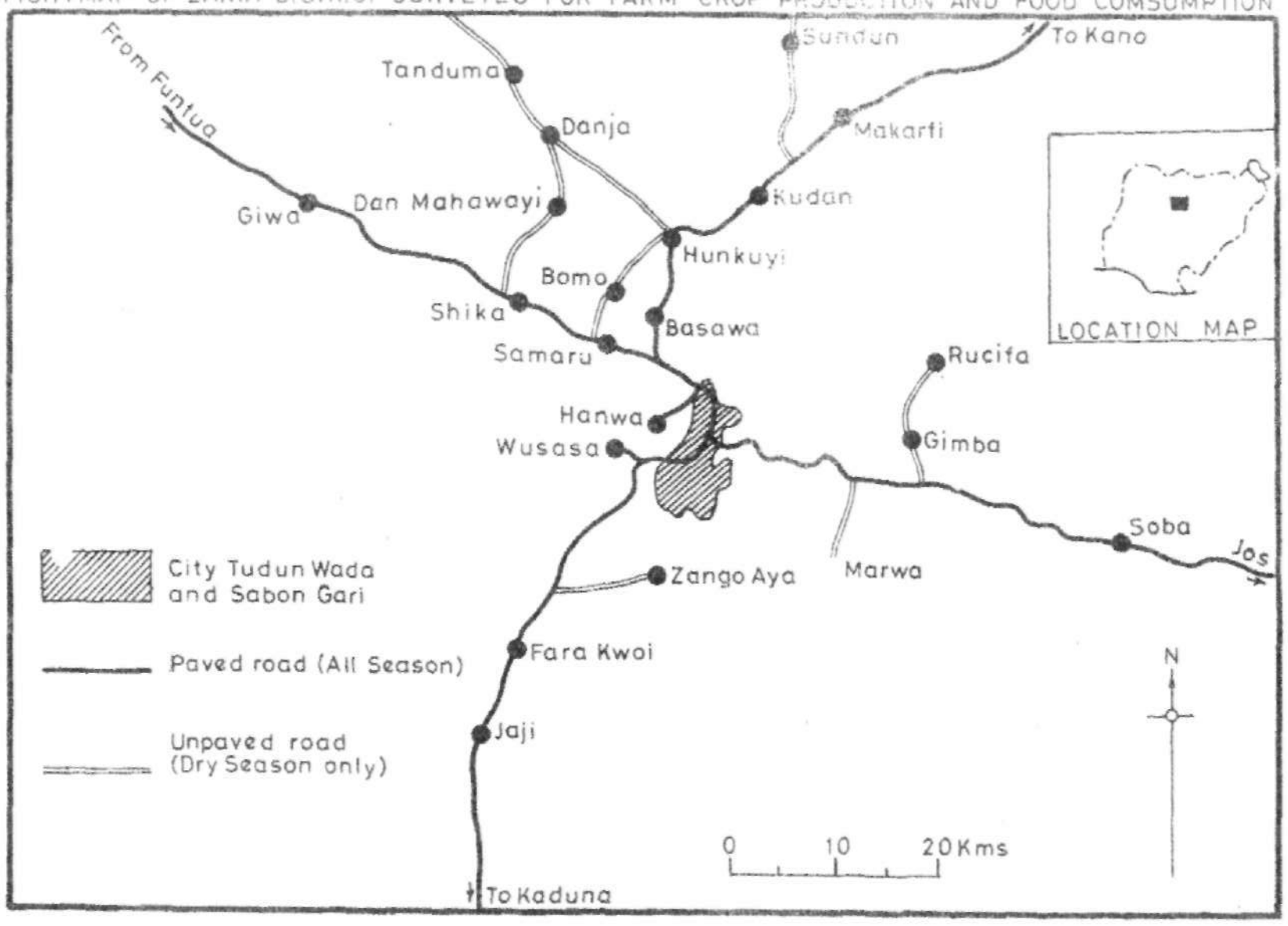
TABLE 21

MEAN DAILY ASCORBIC ACID INTAKE OF CHILDREN AND ADULTS COMPARED WITH THE RECOMMENDED ALLOWANCE

Age Group (years)		Ascorbic acid (mg/day) 2-4	5-7	55-72
Rural	Rainy	54.70	79.11	75.22
	Dry	35.35	40.96	44.70
Sub-urban	Rainy	45.93	61.51	44.03
	Dry	31.23	55.34	35.78
Urban	Rainy	45.25	53.61	36.57
	Dry	37.49	44.45	33.21
*Recommended allowance for all Seasons		15	20	30

* (Idusogie, 1971).

FIG.1: MAP OF ZARIA DISTRICT SURVEYED FOR FARM CROP PRODUCTION AND FOOD COMSUMPTION



CHAPTER III

BIOAVAILABILITY OF DIETARY ASCORBIC ACID IN ADULTS

INTRODUCTION

The relevance of various measurements to the nutrional status for ascorbic acid in humans has been the subject of much controversy. Traditionally the method for the assessment of ascorbic acid status is the measurement of urinary excretion levels of the vitamin at relatively high doses. This "saturation" test is fraught with difficulties, not least, that supplemented individuals excrete in the urine, a substance which reacts chemically as ascorbic acid but which has not yet been identified. The two compounds have been separated by thin-layer chromatography (Hodges et al. 1969). Urinary measurements may also be complicated by a variable, renal threshold or an increase in requirement and utilisation. Large oral doses tend to be reflected rapidly in the plasma and subsequently in the urine without necessarily reflecting tissue saturation (Andrews and Brook, 1969).

The utilisation and metabolism of ascorbic acid by human subjects has been investigated extensively. Several investigators (Ritchey, 1965; Pelletier, 1968; 1970; Milne et al., 1971; Roine et al., 1974; Maclean et al., 1976), reported that

plasma or serum concentration and urinary level of ascorbic acid when considered together gives a good measure of dietary intake. Lowry (1952) reported that intake, blood levels and tissue concentrations of ascorbic acid are directly related when the tissues are above 50 per cent saturated. He also suggested that the ascorbic acid/creatinine ratio in a randomm urine sample might be useful as an index of current dietary intake.

In a survey of twenty healthy adult Nigerians in Ibadan, Oyo State, Reiff (1959) reported that urine and plasma ascorbic acid level were 0.30 to 3.5mg/100ml and 0.37 to 0.75mg/100ml respectively. This report did not indicate the dietary intake of the subjects studied. It was of importance to next investigate whether dietary intakes were matched by biochemical evidence of ascorbic acid status. The study reported here was conducted to evaluate the utilisation of dietary ascorbic acid by a balance study involving assessment of dietary intake, plasma and urinary levels of ascorbic acid in a group of healthy adults. "Kuka" soup was used as the dietary source.

MATERIALS AND METHODS

Subjects

Six healthy male adult volunteers ranging in age from 25 to 41 years participated in the balance study which consisted of three periods:- one untreated and two experimental. All subjects were resident in Samaru, Zaria area. None of the subject had injury on the body or cold or any form of viral infection, neither was any subject on medication during the period of study. The experiment was conducted in the middle of rainy season therefore subjects were not exposed to heat with sweating. The subjects were not exposed to physical stress. The characteristics of the six volunteers is shown in Table 22.

Dietary assessment

The study was conducted in July (the middle of the rainy season) when supplies of ascorbic acid containing foods are plenty (Chapter II). Food intake of subjects during the period of study were recorded using a 24-hour recall method described in Chapter II. Intakes of ascorbic acid were

calculated from a combination of local analyses (Chapter II) and also from the FAO (1968) food composition tables for use in Africa.

"Kuka" Soup

"Kuka" soup was prepared fresh on days 3 and 4 from "kuka" leaves, locust bean cakes, red peppers, onions and potash obtained from the local market. Analysis of the freshly made soup one hour before administration showed that the ascorbic acid contents were 28.75mg and 30.55mg/100g on day 3 and day 4 respectively. The bromosuccinimide method of Evered (1960) was used for the analysis of ascorbic acid of the "kuka" soup. Each subject was given 209g of soup on day 3 and 197g on day 4, so as to ensure provision of 60mg ascorbic acid per dose.

Ascorbic acid tablets

Ascorbic acid tablets (Premier brand)* were analysed by the method of Evered (1960). Five different tablets analysed were found to contain about 30mg ascorbic acid. The tablets were

* Manufactured by Premier Pharmaceutical Products Ltd; V177 Mansfield Batch No.249067.

uncoated but had slightly salty taste. On day 7 and day 8, each subject was given two tablets to provide about 60mg ascorbic acid per dose.

Supplements of soup or ascorbic acid were given at 9.00 a.m. on each occasion and samples of blood and urine were collected three hours later.

Collection of blood

One ml of blood was collected from the radial vein of subjects with hypodermic syringe into blood collecting glass tubes which contained EDTA as anticoagulant. The blood samples were gently mixed with the anticoagulant and was centrifuged in a clinical centrifuge at 3000 r.p.m. The plasma was then separated and centrifuged and refrigerated at 0-4°C. Ascorbic acid content was determined within six hours of collection.

Collection of urine

Samples of urine were collected in glass bottles. No acid or preservative was added to urine samples since all determinations were made within two hours of collection, however, all samples were refrigerated at 4°C prior to analysis.

Biochemical determination

The ascorbic acid content of plasma was estimated by a modification of the dinitrophenylhydrazine method of Gibson et al., (1966). The modifications made were as follows:-

1. The use of 2.5% thiourea instead of 5% thiourea.
2. Four per cent trichloroacetic acid was used instead of 5% TCA.
3. The use of dinitrophenylhydrazine-thiourea reagent instead of dinitrophenylhydrazine-thiourea-copper sulphate reagent.
4. 85% sulphuric acid was used instead of 65% sulphuric acid.
5. Lower concentration of ascorbic acid per ml. were used for the preparation of the Standard Curve (range 0 to 8ug).

The resulting procedure was more sensitive so that Standard Curve could be obtained at lower concentration thus permitting smaller sample size at semi-micro level. A sample size of 0.2ml plasma was needed.

Ascorbic acid content of urine was estimated by the method of Schaffert and Kingsley (1955) and urinary creatinine by the

Jaffe reaction (Taussky, 1954).

Determination of plasma total ascorbic acid - Reagents

1. Ascorbic acid (BDH)
   Standard solution was prepared by dissolving 100mg of ascorbic acid in 4% (W/V) trichloroacetic acid, made to volume of 100ml with TCA solution. Two ml of this stock standard solution was diluted with 4% TCA to 100ml. One ml. of this diluted solution contained 20ug of ascorbic acid.
2. Trichloroacetic acetic 4% (W/V) aqueous solution.
3. Dinitrophenylhydrazine-thiourea reagent. Two g of 2, 4 dinitrophenylhydrazine and 0.25g of thiourea were dissolved in 100ml. of 9N sulphuric acid.
4. Sulphuric acid, 9N.
5. Sulphuric acid 85%.
6. Activated charcoal - one litre of 10% hydrochloric acid was added to 200g of charcoal, boiled and filtered with suction. The cake was stirred with one litre of water and filtered again. It was dried overnight at 100 to 120^{o}C.

7. Activated charcoal in use - 100ml of 5% trichloroacetic acid was added to 5g of acid treated charcoal. The mixture was stirred and allowed to stand for five minutes. The supernatent liquid was decanted and another 100ml. of 5% TCA was added. The dried charcoal was stored for subsequent use.

Procedure

Twenty five ml. of the working standard was shaken vigorously with half teaspoon of charcoal for one minute in an Erlenmeyer flask. The mixture was filtered through Whatman No.42 filter paper. Aliquots of 0.0, 0.05, 0.1, 0.2, 0.3 and 0.4ml. of the filtrate were taken into six test tubes respectively and volumes made to 0.4ml with 4% TCA in each. To each tube 0.1ml of 2, 4 dinitrophenyldydrazine-thiourea reagent was added and incubated for ten minutes in a thermoregulated water bath preheated to 100°C.

The tubes were then chilled in crushed ice. Half ml. of 85% sulphuric acid was added dropwise to each tube, mixed well and allowed to stand for ten minutes to develop colour. The absorbance of the solutions were read in a Colorimeter at 515nm.

A standard curve of absorbance versus concentration of ascorbic acid was drawn (Fig. 8).

To 0.2ml. plasma, 0.4ml of charcoal treated 5% TCA was added. The mixture was then centrifuged and filtered. An aliquot of 0.4ml of the filtrate was treated exactly as in case of Standard solution described above. Duplicate determination were made for each blood sample. Ascorbic acid content was evaluated from the absorbance with reference to the Standard curve.

Determination of urinary ascorbic acid

Ascorbic acid content of the urine was determined by the dinitrophenylhydrazine method of Schaffert and Kingsley (1955) described for food in Chapter II with the following changes. One ml. of urine was diluted to 20 with 4% TCA. One half teaspoon charcoal was added, the mixture shaken well and filtered through a No. 42 Whatman filter paper. Four ml. aliquot of the filtrate was taken and treated exactly as in case of food samples described in Chapter II. Ascorbic acid content was evaluated from the absorbance with reference to the Standard curve.

Determination of urinary creatinine

Reagents:

1. Picric acid 0.04m was prepared by dissolving 9.3g picric acid in 500ml. of water at 80°C. The solution was cooled to room temperature and diluted to one litre with water.
2. Sodium hydroxide 0.75m, 30g of sodium hydroxide pellets was dissolved in water and made up to one litre.
3. Creatinine stock standard (1mg/ml.) 100mg of creatinine (AR) crystals was dissolved in 100ml of 0.1m hydrochloric acid.

   Creatinine working standard (20ug/ml) was prepared by diluting 2ml. of the stock solution to 100ml. with water.
4. Sulphuric acid 0.33m.
5. Sodium tungstate 5g/100ml., 50g of sodium tungstate (AR) was dissolved in water and diluted to one litre

Standardization

Aliquots of 0.0, 0.25, 0.5, 1.0, 2.0, 3.0 and 4.0ml. of the creatinine working Standard were taken into seven test tubes and volumes made to 4ml. with water. One ml. of picric acid solution and one ml. of sodium hydroxide solution were added to each tube respectively. The tubes were allowed to stand for fifteen minutes and the absorbance measured at 500nm. A Standard curve of absorbance versus concentration of creatinine was drawn (Fig. 9).

One ml. of urine was diluted with water to 40ml. volume. One ml. of the diluted urine was added to one ml. of sodium tungstate solution, one ml. of 0.33m H_2SO_4 and one ml. of water. The mixture was mixed thoroughly. Two ml. aliquot of the mixture was made up to four ml. with water and treated exactly as in case of Standard solution described above. Duplicate determinations were made for each urine sample. Creatinine content was evaluated from the absorbance with reference to the Standard curve.

RESULTS AND DISCUSSION

Dietary assessment

The calculated daily intake of ascorbic acid of all subjects is given in Table 23. The mean daily intake ranged from 78.89 to 93.87mg which was very adequate compared with the recommended daily intake of 30mg established by Idusogie (1971). In a previous dietary survey conducted among Military and Police adults in Zaria area (ICNND 1967) a daily intake of 45.0 to 50.7mg ascorbic acid was established. The higher values reported in this study might be due to improvement in food habits and the availability of more vegetables since the study was conducted during the rainy season. This supports the observations reported in Chapter II on the higher intake of ascorbic acid during the rainy season. A second reason could be adduced for the difference in values in this present study and those in the previous study. The previous studied referred to (ICNND 1967) was conducted among subjects, that is, Military and Police recruits whose diets were restricted and controlled as against those of the present study who feed freely on diets of their choice.

No subjects was on vitamin supplement during the study, therefore all ascorbic acid consumed was of dietary origin. Subject one was a smoker who had the least ascorbic acid intake. Although subject 6 had a much higher income than subjects 1 to 5, his ascorbic acid intake was not higher. This difference might be due to the fact that the diet of high income earners tend to contain more meat, fish and cereals while the low income earners eat more vegetables thereby deriving more ascorbic acid from their diet.

Plasma ascorbic acid

Table 24 shows the plasma ascorbic acid values of subjects during the period of study. During the untreated period plasma ascorbic acid level of subjects varied from 0.63 to 1.14mg% (mean 0.89mg%). These findings fall well within the normal range of 0.3 to 1.4mg% established by ICNND (1967). The subjects of this study therefore, constitute a group on "high" level of intake of ascorbic acid according to ICNND (1967) standard. Treatment with 60mg ascorbic acid from "kuka" soup increased the plasma ascorbic acid by 35.9%, while supplementing with ascorbic acid tablet increased the plasma ascorbic acid by

91.0%. These increases show the uptake of ascorbic acid from "kuka" soup and synthetic ascorbic acid tablet.

"Kuka" soup, a popular food supplement of vegetable origin, is a good dietary source of ascorbic acid though not comparable in uptake from the tablet. It is only 40% effective in raising ascorbic acid level in plasma and urine. This low efficiency might be due to some other components of the soup which render the ascorbic acid less readily absorbed.

A relationship was observed between ascorbic acid intake and its plasma level in the subjects. As ascorbic acid intake increased plasma level also increased. Such relationship has also been observed by Hoine et al. (1972), in their study of ascorbic acid intake and plasma level among aged people in Finland. Although the mean intake of ascorbic acid (30.9mg) and plasma level (0.48mg%) were much lower than those reported in this study, the difference could be attributed to the old people studied whose dietary habits are known to be unsatisfactory. However, a relationship was obtained between low dietary intake and low plasma ascorbic acid level. Mclean et al. (1976) also observed a highly significant correlation between ascorbic acid intake and plasma level in elderly men living in New Zealand.

In this present study, subject one was found to smoke 10 to 15 cigarettes per day and his plasma ascorbic acid was lower than other subjects in the study. This has also been reported by Pelletier (1970) in a study of the utilisation of ascorbic acid by smokers and non-smokers. He gave supporting evidence that smokers, in comparison to non-smokers, have low plasma ascorbic acid and retain more of the vitamin from load test. It might be inferred therefore that plasma ascorbic acid levels in man are reasonable indices of intake at high level.

Urinary excretion of ascorbic acid

The data on urinary excretion of ascorbic acid by all experimental volunteers is shown in Table 25. During the untreated period, urinary excretion ranged from 31.25 to 106.40 mg/g creatinine (mean 65.9mg/g creatinine). The excretion in individual subjects varied from the mean of the group. Subject one who is a smoker had the least excretion 31.25mg/g creatinine. The lower excretion value of this particular subject reflect great utilization and storage than for other subjects. The claim by Reiff (1959) that urinary volume of 1,300mls. per day could be safely assumed for adults at Ibadan,

Nigeria is inconceivable since this tends to give a false value of urinary excretion of ascorbic acid. Individuals vary in the amount of urinary output which is a function of season, diet and fluid taken, then the use of a more reliable index such as the amount of creatinine excreted might make the interpretation of urinary ascorbic acid more meaningful. About one g. creatinine is excreted by an adult per day (Lowry, 1952). Therefore urinary ascorbic acid can be expressed per g. creatinine.

When the subjects diet was supplemented with 60mg. ascorbic acid from "kuka" soup, urinary excretion of ascorbic acid increased for all subjects. The mean increase for all subjects was 63.13%. A higher rise in excretion (mean 151.29%) occurred when subjects were treated with ascorbic acid tablets. Although both "kuka" soup and ascorbic acid tablet produced a rise in ascorbic acid excretion, the soup was only 42% effective when compared with the tablet. The result of this study offers some support to the work of Ritchey (1965) who reported that urinary excretion of ascorbic acid increased with intake in preadolescent children. The subjects in this study were "high" in blood level, cumulating in low tissue retention and consequently high excretion. This may not be so with subjects on deficient diet

with poor tissue storage. Under these circumstances, tissue retention will then increase and less ascorbic acid will be excreted. Figure 10 shows changes in plasma and urinary levels of ascorbic acid of subjects when fed on "kuka" soup and ascorbic acid tablet. At low blood level, more ascorbic acid was retained by the tissue and consequently there was lower excretion of ascorbic acid. Conversely at higher blood level tissue retention was lower and higher amounts of ascorbic acid was excreted.

In conclusion, treatment of human adults with 60mg. ascorbic acid from "kuka" soup or ascorbic acid tablet resulted in increased plasma and urinary ascorbic acid. The uptake of ascorbic acid in synthetic form (tablet) is significantly ($P < .05$) higher than those of vegetables.

SUMMARY

The bioavailability of dietary ascorbic acid was studied in a group of six healthy male volunteers by a balance study involving assessment of dietary intake, plasma and urinary levels of ascorbic acid. Diets of subjects provided a daily

mean of 102.6mg. ascorbic acid during the untreated period. Corresponding values of plasma and urinary ascorbic acid were 0.89mg.% and 65.90mg./g. creatinine respectively. Treatment of subjects with 60mg. ascorbic acid from "kuka" soup increased the plasma and urinary ascorbic acid to 1.21mg% and 107.45mg/g. creatinine respectively. Average plasma ascorbic acid and urinary ascorbic acid were 1.71mg.% and 165.60mg./g. creatinine when subjects were given 60mg. supplemental ascorbic acid tablet.

Uptake of ascorbic acid from "kuka" soup was about 40% compared with tablet as judged from changes in blood level with subjects, not deficient in ascorbic acid intake.

TABLE 22

CHARACTERISTICS OF SIX VOLUNTEERS FOR THE STUDY OF BIOAVAILABILITY OF ASCORBIC ACID

SUBJECT	1	2	3	4	5	6
Age	28	25	26	28	27	41
Body Weight (Kg.)	60	55	67	65	68	65
Height (M.)	1.58	1.59	2.07	1.72	2.13	1.68
Monthly Income (₦)	128.50	113.0	110.0	128.50	113.0	901.0
Cigarettes per day	10-15	Nil	Nil	Nil	Nil	Nil

TABLE 23

ASCORBIC ACID INTAKE CALCULATED FROM FOOD TABLES OF SIX VOLUNTERRS FOR THE STUDY ON BIOAVAILABILITY OF ASCORBIC ACID

Subject Number	Untreated		"Kuka Soup*		Ascorbic acid tablet*		Mean
	day 1	day 2	day 3	day 4	day 7	day 8	
1	85.32	89.10	70.44	78.24	72.51	77.74	78.89
2	104.62	109.01	92.39	89.46	75.03	77.03	91.26
3	94.32	99.71	59.00	69.79	79.12	83.04	80.83
4	98.29	100.56	85.76	88.03	92.90	101.52	94.51
5	117.80	122.42	74.63	82.71	80.38	85.27	93.87
6	95.39	100.74	85.02	85.75	88.24	91.18	91.05

* On days 3 and 4 intake was supplemented with 60mg. ascorbic acid from "kuka" soup.
On days 7 and 8 intake was supplemented with 60mg. ascorbic acid from ascorbic acid tablet.

TABLE 24

PLASMA ASCORBIC ACID OF HUMAN VOLUNTERRS THREE HOURS AFTER EXPERIMENTAL TREATMENT

Subject Number	Plasma ascorbic acid (mg%) 3 hours after treatment					
	Untreated		"Kuka" Soup*		Ascorbic acid tablet*	
	day 1	day 2	day 3	day 4	day 7	day 8
1	0.63	0.72	1.02	1.03	1.33	1.45
2	1.02	1.05	1.28	1.25	1.63	1.65
3	0.85	0.74	0.90	1.02	1.55	1.61
4	0.73	0.94	1.57	1.55	2.00	2.50
5	0.90	0.97	1.01	1.12	1.85	1.87
6	1.14	1.02	1.39	1.43	1.56	1.77
Mean	0.88	0.91	1.20	1.23	1.65	1.77

* Supplement equivalent to 60mg ascorbic acid per dose.

TABLE 25

URINARY EXCRETION OF ASCORBIC ACID BY HUMAN VOLUNTEERS THREE HOURS AFTER EXPERIMENTAL TREATMENT

Subject Number	Urinary ascorbic acid (mg/g. creatinine) 3 hours after treatment*					
	Untreated		"Kuka" Soup		Ascorbic acid tablet	
	day 1	day 2	day 3	day 4	day 7	day 8
1	31.25	40.09	105.00	93.01	129.40	138.80
2	76.92	84.28	118.72	184.61	190.32	203.14
3	32,26	33.67	87.50	84.37	137.90	141.42
4	85.94	89.21	105.26	105.17	170.17	176 40
5	55.05	50.72	75.00	77.82	166.63	179.42
6	105.00	106.40	125.14	127.80	172.41	181.13
Mean	64.40	67.40	102.77	112.13	161.14	170.05

* Treatment in each case is equivalent to 60mg. ascorbic acid per dose.

CHAPTER IV

SEASONAL VARIATION IN ASCORBIC ACID CONTENT OF SELECTED VEGETABLES PRODUCED IN ZARIA LOCALITY

INTRODUCTION

Vegetables are the main sources of ascorbic acid in the diets of Northern Nigerians. The production of fruits and vegetables is seasonal and fluctuates from plenty in rainy season to scarcity in dry season.

In the Northern States the dry season is characterised by intense sunshine, high temperatures, low relative humidity and low soil moisture. Many plants loose leaves and make little growth during the period. It usually lasts from mid-October to mid-May. This period marks the period of paucity of fresh vegetables.

The seasonality of fresh vegetables was recognised as a serious set back in the diet of Nigerians. Since 1961 a scheme called, Dry Season Vegetable Drive has been launched by the Market Garden, Enugu. At the experimental stages of the work, limiting factors were taken into account in developing the techniques employed during the dry season production. Such factors include irrigability of the site, a lot of mulch for reducing soil evaporation stress, organic matter and fertilisers to ensure good root growth and vegetable rigour. Sometimes

partial shading was necessary to cut off excessive solar heat (Dema, 1965). Farmers in the northern States have practiced dry season vegetable production successfully along riverine areas and on irrigated farms.

Manurial conditions, nitrogen fertilization climate and seasonal variation are all influencing factors which determine the amount of ascorbic acid in plants (Kitagawa 1973). Taylor et al. (1975), reported that nitrogen fertilisation did not significantly improve the ascorbic acid content of some Nigerian leafy vegetables although the ascorbic acid yield for Amaranthus caudatus and Curcubita pepo increased with age reaching a peak in the 9th week. In a study on the ascorbic acid content of four varieties of oranges, it was reported that the vitamin increased gradually from the beginning of November till the middle of December, a period of dry season when soil moisture was always very low (Ogunmodede 1975).

In view of the paucity of reports on seasonal variations of ascorbic acid in fruits and vegetables, the present study was conducted to find if there is any seasonal variation in ascorbic acid content of vegetables produced during dry and rainy season.

MATERIALS AND METHOD

Twenty farms located within forty kilometers radius of Zaria were selected for this study. These were in riverine areas and produce vegetables all year round because of the availability of water from nearby streams. Samples of vegetables were taken from these farms in order to average variances in the soil, climate, fertilizers and other cultural practices.

Fresh samples of pumpkin, spinach, bitterleaf, sorrell leaves, tomatoes, red peppers, okro, "kalkashi" and "yalo" were obtained from the various selected farms at maturity six times each during the dry and rainy seasons for consecutive two years. Samples of each type of vegetables were pooled. Representative samples were taken from each and moisture content determined by standardised methods as published in the official methods of Analysis of the Association of Official Analytical Chemists (AOAC) (1975). Ascorbic acid content of the vegetable samples was determined using bromosuccinic acid as described by Evered (1960), as described on page 57.

Statistical Analysis

A student's t-test as described by Snedecor and Cochran (1971) was performed to test any significant differences between means of ascorbic acid content of the vegetables during the dry and rainy seasons (Appendix 22).

RESULTS

The mean values of the moisture contents and ascorbic acid contents of selected vegetables for two years are shown in (Table 22). Values for each year are shown in detail in Appendix 19-21. All the vegetables were succulent with moisture content ranging from 90.37% in pumpkin to 81.65% in "kalkashi". Moisture content decreased during the dry season in all vegetables except tomatoes which is a dry season crop.

The vegetables selected for this study are all rich sources of ascorbic acid with values ranging from 151.34mg% in red peppers to 22.50mg% in "yalo". Ascorbic acid decreased during the dry season in all vegetables but this decrease was only significant ($P < 0.05$) in red peppers and okro. Although a lot of variation was noticed in the ascorbic acid content of the

vegetables collected from one farm to the other, the differences from one year to the other was not significant since there was no climatic hazard during the two years of study.

DISCUSSION

The practice of dry season farming has reduced the seasonal fluctuation in vegetable production. Although yield per hectare is considerably reduced in dry season when compared to rainy season farming, the composition of the vegetables in terms of moisture and ascorbic acid have not been different.

In previous work (Chapter II and III), food sampling was done in the homes and market places and some of the vegetables sampled had wilted or had been beaten by sun. Literature shows that these factors affect ascorbic acid content of vegetable (Oke 1967). It is therefore not surprising that the values obtained in present study differ from these reported in Chapter II. The correlation between increasing moisture and ascorbic acid contents reported is in agreement with the observation of Takama et al. (1973).

Irrigation of farms and the use of mulch for reducing soil evaporation have enhanced the retention of water by dry season

vegetables such that there is no significant difference in moisture content both during the dry and rainy seasons. Tomatoes grown during the rainy season are picked when matured green and contain maximum ascorbic acid. They are then ripened at home before being transported to distant markets. This practice has been shown to reduce their ascorbic acid from 25 to 30 per cent compared with tomatoes ripened on the plant (Markakis et al. 1974). The practice of picking mature green tomatoes prevents the spoilage of the vegetable by excessive rains, however, maximum ascorbic acid could be derived from these tomatoes if they are consumed green.

Ascorbic acid content of vegetables grown during the rainy season did not differ significantly from that produced during dry season except in red peppers and okoro ($P<0.05$). Lack of any signficant difference in ascorbic acid content of vegetables grown in these two years might probably be due to the fact that there was no climatic difference in the two years like might be observed in drought as occured in Nigeria in 1972.

The significance of these findings is that farmers could be encouraged to grow vegetables during the dry season if they could be aided with construction of dams for irrigated farming during this period. This wise there will be less scarcity of

fresh vegetables in the dry season and dietary ascorbic acid will be nearly constant all year round.

SUMMARY

The variation in moisture and ascorbic acid content of nine vegetables grown during dry and rainy seasons was studied. Vegetables were obtained fresh and at maturity from twenty different farms. Moisture and ascorbic acid contents were determined in the vegetables produced during dry and rainy seasons.

Moisture content in the rainy season ranged from 90.37% in pumpkin to 81.65% in "kalkashi". Moisture decreased in all vegetables during the dry season except in tomatoes. The ascorbic acid content of the vegetables produced during the rainy season ranged from 151.34mg/100g in red peppers to 29.50mg%. Lower ascorbic acid values were noted in vegetables of the dry season but this decrease was significant ($P < 0.05$) only in case of red peppers and okro.

It was concluded that moisture and ascorbic acid of vegetables grown during rainy season are higher than in the same vegetables grown during the dry season. The need for expanded

dry season farming to augument ascorbic acid consumption is emphasised.

TABLE 26

THE MEAN VALUES OF MOISTURE AND ASCORBIC ACID CONTENTS OF SELECTED VEGETABLES PRODUCED IN THE FARMS AROUND ZARIA DURING DRY AND RAINY SEASONS

VEGETABLES		MOISTURE CONTENT (%)		ASCORBIC ACID CONTENT (mg/100g edible portion)	
Local Name	Botanical Name	Dry Season	Rainy Season	Dry Season	Rainy Season
Pumpkin	Curcubita pepo	90.04	90.37	49.32	52.60
Spinach	Amaranthus candatus	83.01	83.07	68.45	71.45
Bitterleaf	Vernonia amygalina	82.39	84.12	64.29	72.88
Sorrel leaves	Hibiscus sabdariffa	82.75	83.54	54.30	62.03
Tomatoes	Lycopersium esculentum	89.37	89.01	82.05	84.42
Red peppers	Capsicum spp	83.95	84.05	120.10	161.34
Okro	Hibiscus esculentum	85.97	86.77	42.61	60.84
"Kalkashi"	Corchorus spp	81.37	81.65	49.32	54.10
"Yalo"	Solanum melongeana	86.18	86.88	27.46	29.50

CHAPTER V

EFFECT OF COOKING, STORAGE AND REHEATING ON ASCORBIC ACID RETENTION OF VEGETABLE SOUPS

INTRODUCTION

Leafy vegetables are the major source of ascorbic acid in the Nigerian diet because of the seasonal availability of fruits. Some of the vegetables which provide ascorbic acid are okro (Hibiscus esculentum), baobab leaves (Andasonia digitata), sorrell leaves (Hibiscus spp) and spinach (Amaranthus candatus). Generally these vegetables are made into soups and consumed with starchy moulds. However, in some cases, vegetables such as "rama" and "zogale" may be boiled, salted and eaten as such, quite similar to the way cabbage, broccolli and asparagus are consumed in temperate countries.

Some vegetables such as spinach, "soko" and bitterleaf are pre-boiled and drained before being made into soups. Loss of ascorbic acid during boiling of vegetable has been reported in the literature (Oke, 1966b, 1967, Herrmann et al., 1973; Domah et al., 1974; Herrmann et al., 1974; Sood and Bhat, 1974). Other vegetables such as okro, "kalkashi" and baobab leaves are cooked directly as soups.

Traditionally when soups are made, they may be consumed wholly in a meal or the left over preserved for subsequent meals.

Soups thus preserved are heated to boiling before each meal and may therefore be heated two or three times daily until the entire soup is totally consumed.

No information is available on the extent of loss of ascorbic acid that occur when soups are made and stored and reheated by the usual household methods. This study was conducted to determine ascorbic acid loss in vegetables during boiling, soupmaking, storage and the reheating of stored soups before subsequent consumption.

MATERIALS AND METHODS

Vegetables

Samples of fresh baobab leaves, sorrell leaves, "soko" "kalkashi", okro, spinach, bitterleaf, "rama", "zogale", tomatoes, red peppers, onions and locust bean cake obtained from the local markets were used for the study.

Pre-boiling of vegetables

Samples of spinach, "soko", "rama", "zogale" and bitterleaf weighing 110g was used for each examination. Before pre-boiling

10g sample of each vegetable was removed and analysed for ascorbic acid by the N-bromosuecinimide method of Evered (1960) described in Chapter II. The remaining portion weighing 100g was cooked in the requisite quantity of water until done. The quantity of water used, the time required for boiling each vegetable are shown in Table 27. These were established during a preliminary period to standardise the procedure. At the end of the cooking period, the vegetables were drained. Fifty ml. portions of cooking water and 10g portions of the cooked vegetables were analysed for ascorbic acid from each preparation.

Soup preparation

Four vegetable soups:- "Kalkashi", "kuka", okro, "miyan taushe" and a stew were prepared in the native procedure described in the appendix. The weights of ingredients used for each soup are reported in Appendix 24. "Kalkashi", "kuka" and okro soups were cooked for fifteen minutes each, while "miyan taushe" and stew were cooked for forty five minutes each. "Tower"* aluminium pots with tight lids were used as containers.

---

* "Tower" is the brand name for aluminium pots made by Alumaco Nig. Ltd;, Lagos.

Storage of soups

Samples of vegetable soups and stew were stored in covered aluminium pots. The pots were kept in cupboards at room temperature ($78^{\circ}F$) in order to simulate the usual household practice. Storage lasted 48 hours.

Ascorbic acid analysis

Ascorbic acid content of the raw ingredients and samples of freshly cooked soups were determined using the method of Evered (1960). Soups were subsequently sampled every twelve hours before and after heating to boiling for about five minutes and samples were analysed for ascorbic acid.

RESULTS

Pre-boiled vegetables

The ascorbic acid content in raw and boiled vegetables is reported in Table 27. "Soko" cooked for eight minutes had the highest ascorbic acid retention (61.03%) and bitterleaf cooked for eighteen minutes had the least retention (21.74%). The

recovery of ascorbic acid in the cooking water increased ($P < 0.01$) with increasing cooking time and the amount of cooking water.

Soups

The ascorbic acid content of the composite ingredients of the soups varied from 45.1mg% in "miyan taushe" to 84.4mg% in "kuka". At the end of the preparation, ascorbic acid loss were 94.63%, 88.44%, 69.97%, 66.16% and 73.33% in stew, "miyan taushe" okro, "kuka" and "kalkashi" soups respectively.

Storage and reheating of soups

Storage and heating of these vegetable soups and stew resulted in further loss of ascorbic acid. When stored for 12 hours complete loss of ascorbic acid occurred in the stew while "miyan taushe" soup retained only 0.71mg prior to heating but no more detectable after heating. At the end of 48 hours storage only "kalkashi" and okro had any ascorbic acid left prior to heating but became negligible after heating (Table 29).

DISCUSSION

The high solubility of ascorbic acid in water and the relative ease with which it is oxidised, makes this vitamin particularly susceptible to processing conditions. Extraction of this vitamin takes place rapidly under normal conditions of boiling (Wilson et al., 1974). Although an appreciable amount of ascorbic acid is lost during cooking of vegetables, the amount retained by the resultant soup constitute a significant amount especially among Nigerians who consume 200-300g of freshly prepared soup.

As shown in this study, maximum ascorbic acid can only be obtained, from these vegetable soups if they are consumed when freshly made. For example an adult Nigerian who consumes 200g of freshly made okro, "kuka" or "kalkashi" soup in a day derives 37.16mg, 57.11mg or 37.50mg ascorbic acid respectively each of which already satisfies his daily requirement of about 30mg. Similarly the same soups consumed after 12 hours of storage provide 23.52mg, 14.12mg or 21.18mg respectively. The consumption of foods left overnight as morning meals has been reported from some of the residents of Zaria district in Chapter II.

Such meals consisted of starchy moulds made from cereal or root tubers and reheated soups. In families where okro, "kuka" or "kalkashi" soups is a component of the left-overs used for breakfast, ascorbic acid intake from these soups are 11.9mg, 7.80mg or 15.6mg respectively per 200g consumable soup. Where "miyan taushe" or stew is consumed as left-over meal, these soups do not contribute any appreciable amount of ascorbic acid to the diet after storage for over 12 hours.

"Miyan taushe" and stew had the highest amount of ascorbic acid in the raw composite but they showed the least retention after cooking probably due to longer cooking time. Traditionally these soups are cooked for a longer time compared to okro, "kuka" and "kalkashi" in order to prolong their shelf lives. In order to derive any ascorbic acid from the stew and "miyan taushe", they must be consumed soon after cooking. "Kalkashi" and okro soups though had lower ascorbic acid values after cooking than, "kuka" soup yet retained more ascorbic acid on storage. Okro soup was eaten frequently by the wage earners respondents from the sub-urban and urban populations (Chapter II). These group of respondents store their soups to some extent because of the demand of their jobs, However, no storage lasts more than 36 to

48 hours because the soups stale fast and their acceptability is reduced after 48 hours. Therefore an adult who consumes 200g of okro soup after 36 hours of storage derives 5.36mg ascorbic acid and only negligible amount after 48 hours of storage.

Among the Hausas and Fulani respondents "kuka" soup is a favourite and it is consumed at least once a day. This soup retained the highest amount of ascorbic acid after cooking but the loss is rapid on storage. Traditionally "kuka" soup is not stored for more than 24 hours, the leaves are readily available and the soup can be made everyday at minimum cost. Owing to the regularity of consumption of "kuka" soup may contribute 7.80mg to 57.14mg ascorbic acid to the diet of an adult when consumed within 24 hours of preparation.

The traditional method of pre-boiling vegetables such as spinach, "soko" and bitterleaf before they are made into soups constitutes a significant loss of ascorbic acid as reported by Oke (1967) and also confirmed by the results of this study. Ascorbic acid loss in this traditional method of cooking as reported by Bender (1967), may be due to some factors such as enzymic oxidation during the time lag between preparation and cooking and leaching into the cooking liquid because these

vegetables are traditionally cooked over a long time. The general practice of cooking vegetables and other foodstuffs in open pots also exposes them to loss of ascorbic acid by atmospheric oxidation.

SUMMARY

The effect of cooking and storage on ascorbic acid retention of some Nigerian vegetable soups was studied. Ascorbic acid was determined in the raw ingredients in the boiled vegetables in the cooked soups and subsequently before and after reheating at twelve hours storage at room temperature.

Effect of pre-boiling showed that maximum amount of ascorbic acid (61.03%) was retained when "soko" was boiled for eight minutes and minimum ascorbic acid (21.74%) was retained by bitterleaf boiled for eighteen minutes. The markedly lower ascorbic acid values in the cooked vegetables as compared to the fresh ones was supposedly due to atmospheric oxidation and leaching into the cooking water.

Maximum ascorbic acid (28.57mg) was retained by freshly cooked "kuka" soup while minimum ascorbic acid (3.13mg) was

retained by stew. Storage and reheating of the soups decreased the ascorbic acid content of the soups. At 24 hours post cooking, "kuka", okro and "kalkashi" had 5.19mg, 7.79mg and 9.09mg ascorbic acid per 100g consumable soup. By 48 hours none of the soups examined had any appreciable amount of ascorbic acid left. The effects of preboiling, cooking and storage of soup on ascorbic acid contents and the values of these soups and their stored products as sources of dietary ascorbic acid are emphasized.

TABLE 27

EFFECT OF BOILING VEGETABLE IN WATER ON THEIR ASCORBIC ACID CONTENT

Vegetables				Ascorbic acid (mg/100g)			
Local name	Botanical name	Cooking water (g)	Cooking time (min.)	Raw	Cooked	Cooking water	Loss due to cooking (%)
Bitter leaf	Vernonia amygalina	891	18	51.5±1.43	14.2±2.63	29.10	78.25
"Soko"	Celosia argentia	589	8	56.2±2.79	44.3±5.09	6.8	38.97
Spinach	Amaranthus candatus	640	10	53.4±9.42	10.6±1.34	2.7	70.79
"Rama"	Hibiscus cannabinus	502	15	50.1±4.69	14.5±3.40	10.3	43.11
"Zogala"	Moringa pterygosperma	472	16	97.3±2.88	30.4±6.01	15.8	48.19

TABLE 28

EFFECT OF COOKING INTO SOUPS ON ASCORBIC ACID CONTENT OF VEGETABLE

Vegetable 100g portion	Total Ascorbic Acid content (mg)		
	Uncooked	Cooked*	Loss due to cooking (%)
"Kalkashi"	70.3	18.8	73.3
"Kuka"	84.4	28.6	66.2
Okro	61.9	18.6	70.0
"Miyan taushe"	45.1	5.2	88.4
Stew	58.3	3.1	94.6

* Cooked into soup, procedure described in appendix.

TABLE 29

EFFECT OF STORAGE AND REHEATING ON ASCORBIC ACID CONTENT OF VEGETABLE SOUP

Vegetable component of soup*	Ascorbic acid content (mg) of soup after storage (hours)								
	12			24		36		48	
	0	a	b	a	b	a	b	a	b
"Kalkashi"	18.8	14.1	10.6	9.1	7.8	3.9	2.6	1.0	0
"Kuka"	28.6	9.4	7.1	5.2	3.9	0	0	0	0
Okro	18.6	12.9	11.8	7.8	6.0	4.2	2.6	1.0	0
"Miyan taushe"	5.2	0.7	0	0	0	0	0	0	0
Stew	3.1	0.0	0	0	0	0	0	0	0

* 100g vegetable in each case

a before heating

b after heating

CHAPTER VI

EFFECT OF STORAGE ON THE ASCORBIC ACID CONTENTS OF SUN-DRIED VEGETABLES

INTRODUCTION

During storage of dehydrated foods in permeable packages, many changes occur that lead to quality deterioration. An important index in deterioration of dehydrated vegetables is the loss of ascorbic acid. Environmental factors during storage period might affect the rate of loss of this vitamin (Reimer and Karel, 1978). Various leafy vegetables such as bitterleaf (Vernonia amygalina), "Ayoyo" (Corchorus olitorium), spinach (Amaranthus candatus) contain fairly high concentrations of ascorbic acid among all food items commonly used in Nigeria (Oke, 1967).

The production of these vegetables is seasonal, most being produced during the rainy season. In riverine areas however, some fresh quantities are available as a result of irrigation farming in the dry season. Fresh vegetables produced during the dry season are very expensive and therefore many people cannot afford to buy.. These vegetables which are produced in large quantities in the rainy season are therefore sun-dried and stored for use during the dry season. Vegetables can also be stored fresh, but storage has to be done at 10°C rather than at room temperature in order to have a longer shelf-life

(Oluwole and Adedipe, 1978). Oke (1967) reported that sun-drying of some Nigerian vegetables for 3-4 hours caused 47-80 loss of their ascorbic acid content. The work of Giri and Doctor (1938) and Ranganathan (1942) showed that during the process of dehydration, much of the ascorbic acid present in fresh vegetables except amla (Emblica officinalis) is usually destroyed. Ramasastri (1974) however, reported that sun-drying of the fresh pulp of "amla" resulted in the loss of about 30 per cent of ascorbic acid. Loss during storage of the dehydrated powder at room temperature was not marked. The losses were 25 per cent at 20 weeks, 50 per cent at 40 weeks and 60 per cent at 48 weeks of storage.

Dehydrated vegetables form major food items in rural and urban populations for as long as four to eight months during the long spell of the dry season in parts of Nigeria especially in the Zaria district.

Literature lacks information about the keeping quality of ascorbic acid in these dehydrated Nigerian vegetables. This study was conducted to determine the effect of dehydration and of duration of storage on ascorbic acid content of Nigerian vegetables.

MATERIALS AND METHODS

Fresh samples of red peppers, sweet peppers, bitterleaf, sorrell leaves, "kalkashi", "rama", "ayoyo", okro, baobab leaves, and "zogale" were obtained from various markets in the Zaria area. Portions of each type of vegetables collected from different locations were pooled together. Representative samples of each were analysed for content of moisture (A.O.A.C. 1975) and also ascorbic acid by the method described in Chapter III.

The remaining vegetable samples were sun-dried by leaving them in trays outside for three days, their moisutre and subsequent ascorbic acid contents were estimated. Samples were stored in large wide mouth screw capped bottles at room temperature for a period of six months. Representative samples were taken at monthly intervals and content of their moisture and ascorbic acid were determined.

RESULTS

Results obtained on the effect of sun-drying of Nigerian vegetables are given in Table 25. All the vegetables are rich sources of ascorbic acid. Apart from the peppers, "zogale" leaves had the highest content with an average of 101.8mg/100g.

The vegetables were also very succulent with moisture content ranging between 76.5 and 86.4 per cent.

On sun-drying appreciable amounts of ascorbic acid and moisture were lost. "Rama" was most susceptible to drying, loosing as much as 98.5 per cent of its moisture content, it however, had the least ascorbic acid loss of 21.3 per cent. Fresh red peppers with an ascorbic acid average of 153.1mg/100g had the highest loss of 58.0 per cent on sun-drying.

The effect of storage on the moisture content of the dehydrated vegerable is shown in Table 26. At the end of one month of storage, losses varied from 0-12.5 per cent. At the end of six months storage moisture retention varied from as low as 28.5 per cent in baobab leaves to as high as 70 per cent in okro.

The effect of storage on the ascorbic acid retention of dehydrated vegetables is shown in Table 27. In all the vegetables, ascorbic acid content decreased throughout the storage period. At the end of six months' storage, "zogale" had the highest (58.4%) retention of ascorbic acid, while "kalkashi" had the least (35.4%). It was observed that ascorbic acid retention decreased ($P < 0.01$) with increasing length of storage of the dehydrated product.

DISCUSSION

A major nutritional value of vegetables is their ascorbic acid content. In the Northern States of Nigeria, vegetables are the largest source of ascorbic acid.

The long spell of the dry season lasting from mid September to April in the northern States results in the scarcity of fresh vegetables. During this period most households consume dried vegetables. Drying and storage provide a considerable improvement on the shelf-life of vegetables but is sometimes accompanied by nutrient loss. On the other hand, storage of fresh vegetables at 10°C improved shelf-life and retained more ascorbic acid (Oluwole and Adedipe, 1978). However, this is beyond the reach of the poorer people, also the amount that can be preserved is very limited. It is also necessary to emphasize here that Oluwole's storage was for limited time because even at that temperature, not many vegetables can be preserved for more than a few weeks without spoilage. In view of the above difficulties, drying becomes the most useful method of preservation for people who do not have fresh vegetables for about four to six months of the year. Ascorbic acid occurs within the tissue of the vegetables

and as long as the cells are intact little loss occurs, but when allowed to dry through loss of water, the loss is appreciable. It is noteworthy that "Rama", "Kalkashi" and "Ayoyo" which had low moisture content tend to loose less ascorbic acid on sun-drying than others.

Within the first month of storage, ascorbic acid content decreased rapidly in all the vegetables except okro and zogale. Similar observations were reported by Nagy and Smoot (1977) while studying the effect of storage on retention of ascorbic acid in canned single strength orange juice. Such an initial rapid loss has been shown to be due to oxidation by a residual air layer trapped within the storage containers (Kefford, MacKenzie and Thompson, 1959). After this initial loss, ascorbic acid was degraded anaerobically.

At the end of six months storage, bitterleaf, okro and zogale still retained over fifty per cent of their ascorbic acid while baobab leaves retained 44.9%. It would thus appear that although baobab leaves retained less ascorbic acid than bitterleaf and zogale, the preference of this vegetable enables it to contribute more ascorbic acid to the diet of the people. It was also observed that during this prolonged storage the dehydrated vegetables underwent non-enzymic browning which

usually makes the determination of ascorbic acid difficult. This was particularly noticeable in bitterleaf, sorrell leaf, red peppers and sweet peppers. A similar observation has been made by Berry and Tatum (1965). Tatum et al. (1967) reported the identification of 16 non-enzymic browning products from stored orange juice powder. Two of the constituents of these citrus powders which are likely to be precurssors of these browning products are ascorbic acid and fructose (Lamden and Harris, 1950). This probably accounts for some loss of ascorbic acid in the stored dehydrated products.

There was a correlation between moisture content of the dehydrated vegetables and ascorbic acid retention. High moisture levels in the dehydrated vegetables is detrimental to ascorbic acid retention. This observation is similar to that reported by Miers et al. (1958) in spray-dried tomatoes.

In conclusion, sun-drying followed by storage of vegetables at room temperature have been shown to reduce the moisutre and ascorbic acid content of the vegetables.

Within the rural population of Zaria area the recommended allowance of ascorbic acid was met during the dry season when dried and stored vegetables contributed 70 to 80 per cent of the total ascorbic acid intake (Chapter III). The implications of

this study are that although dehydration and storage reduce ascorbic acid content of vegetables, these vegetables still contain appreciable amounts of ascorbic acid which augments the intake of this vitamin during dry season when fresh vegetables are scarce.

SUMMARY

The effect of sun-drying and storage on the ascorbic acid content of ten vegetables commonly produced and consumed in the Northern States of Nigeria was studied. Vegetables were analysed when fresh, sun-dried and stored at room temperature. Moisture and ascorbic acid contents of the dehydrated vegetables were determined at monthly intervals.

The ascorbic acid content of the fresh vegetables ranged from 153.1 to 52.7mg/100g. On sun-drying 21 to 58 per cent of the ascorbic acid was lost while further 42 to 66 per cent was lost on storage for six months. Ascorbic acid was most retained (58.4%) in stored dehydrated "zogale" and was least retained (35.4%) in stored dehydrated "kalkashi". Ascorbic acid retention in the stored dehydrated vegetables decreased with increasing moisture content of the vegetables. Total

ascorbic acid retention was significantly ($P < 0.01$) affected by length of storage.

It was concluded that dehydrated vegetables stored for six months still retained some ascorbic acid which contributed 70 to 80 per cent of this vitamin intake among rural population during dry season.

TABLE 30

EFFECT OF SUN-DRYING ON MOISTURE AND ASCORBIC CONTENTS OF VEGETABLES PRODUCED IN ZARIA LOCALITY

Vegetable		Moisture (%)			Ascorbic acid (mg/100g)		
Local Name	Botanical Name	Fresh vegetable	Sun-dried vegetable	Loss due to sun-drying	Fresh vegetable	Sun-dried vegetable	Loss due to sun-drying
Red pepper	Capsicum sp.	81.1	5.7	92.9	153.1	64.3	59.0
Sweet peppers	Capsicum annu	83.6	4.7	94.3	135.3	69.7	48.5
Bitterleaf	Vernonia amygalina	83.2	3.4	95.9	64.1	28.9	54.9
Sorrell leaf	Hibiscus sabdariffa	82.7	1.5	98.2	57.8	38.5	33.4
"Rama"	Hibiscus cannabinus	77.5	1.2	98.5	52.7	41.5	21.3
"Kalkashi"	Corchorus sp.	78.3	3.3.	95.8	48.9	35.5	27.4
"Ayoyo"	Corchorus olutorium	79.6	3.1	96.1	52.3	38.6	26.2
Okro	Hibiscus esculentum	86.4	2.0	97.7	57.3	31.7	44.7
Bacbab leaf	Adansonia digitata	75.3	3.5	95.4	75.8	49.2	35.1
"Zogale"	Moringa pterygosperma	76.5	2.2	97.1	101.8	53.2	47.7

TABLE 31

EFFECT OF STORAGE ON MOISTURE RETENTION (%) OF SUN-DRIED VEGETABLES

Vegetable		Mc* of sun-dried vegetable %	Months of storage at room temperature											
			0-1		1-2		2-3		3-4		4-5		5-6	
Local Name	Botanical Name		Mc*	R**	Mc*	R**	Mc*	R**	Mc*	R**	Mc*	R**	Mc*	R**
Red peppers	Capsicum spp	5.7	5.2	91.2	4.5	78.9	4.7	82.4	4.2	73.6	4.0	70.1	3.7	64.9
Sweet peppers	Capsicum annum	4.7	4.4	93.6	4.5	95.7	3.0	63.8	2.8	63.6	2.9	59.5	2.7	57.4
Bitter-leaf	Vernonia amygalina	3.4	3.2	94.1	4.1	120.5	2.8	82.3	2.7	84.3	2.2	64.7	2.2	64.7
Sorrell leaf	Hibiscus sabdarrifa	2.5	2.3	92.0	2.0	80.0	2.9	116.0	1.9	76.0	1.8	72.0	1.6	64.0
"Rama"	Hibiscus cannabinus	1.2	1.0	88.3	1.3	108.3	1.2	100.0	1.0	83.3	0.9	75.0	0.8	66.6
"Kalkashi"	Corchorus spp	3.3	3.1	93.9	3.2	96.9	3.0	90.9	2.9	87.8	2.7	81.8	2.0	60.6
"Ayoyo"	Corchorus oliforium	3.1	2.9	93.5	2.4	77.4	2.6	83.8	2.1	67.7	1.8	58.0	1.7	54.8
Okro	Hibiscus esculentum	2.0	2.0	100	2.2	110.0	1.8	90.0	1.6	80.0	1.5	75.0	1.4	70.0
Baobab leaves	Andasonia digitata	3.5	3.4	97.1	2.4	68.5	1.6	45.7	1.8	51.4	1.5	42.8	1.0	28.5
"Zogale"	Moringa pterygosperma	3.2	2.8	87.5	2.6	81.2	2.0	62.5	1.9	59.3	1.7	53.1	1.4	43.7

* Mc = Moisture content; **R = Retention

TABLE 32
EFFECT OF STORAGE ON ASCORBIC ACID (%) OF SUN-DRIED VEGETABLES

Vegetable		Aa* of dehydrated vegetable (mg/100g)	Months of storage											
			0-1		1-2		2-3		3-4		4-5		5-6	
Local Name	Botanical Name		Aa* mg/100g	R**	Aa* mg/100g	R**	Aa* mg/100g	R**	Aa* mg/100g	R**	Aa* mg/100g	R**	Aa* mg/100g	R**
Red peppers	Capsicum spp	64.3	45.2	70.3	38.6	60.0	31.1	48.4	29.0	45.1	27.8	43.2	25.8	39.3
Sweet peppers	Capsicum annum	69.7	39.3	56.4	38.6	55.4	36.2	51.9	35.4	50.8	32.7	47.2	31.2	44.8
Bitter leaf	Vernonia amygalina	28.9	19.1	66.1	18.3	63.3	18.0	62.3	17.7	61.2	16.9	58.5	16.7	57.8
Sorrell leaf	Hibiscus sabdarrifa	38.5	25.4	65.9	19.3	50.1	18.8	48.8	18.1	47.0	17.2	44.7	15.0	38.9
"Rama"	Hibiscus cannabinus	41.5	31.7	76.4	24.6	59.2	20.3	48.9	18.7	45.1	17.1	41.2	15.3	36.9
"Kalkashi"	Corchorus spp	35.5	25.3	71.3	24.9	70.1	19.1	53.8	16.8	47.3	15.2	42.8	12.5	35.4
"Ayoyo"	Corchorus oliforium	32.1	25.7	80.0	25.6	79.8	21.3	66.4	17.4	54.2	14.9	46.4	12.8	39.8
Okro	Hibiscus esculentium	31.7	30.6	96.5	30.1	94.9	26.3	82.9	23.7	74.8	20.2	63.7	18.4	58.2
Baobab leaves	Andasonia digitata	70.9	59.2	83.5	51.6	72.8	49.0	69.1	43.7	61.6	39.6	55.8	31.9	44.9
"Zogale"	Moringa pterygosperma	53.2	51.9	97.5	48.3	90.8	42.8	80.5	38.7	72.7	33.1	62.2	31.1	58.4

*Aa = Ascorbic acid; R** = Retention

CHAPTER VII

THE INCIDENCE OF CLINICAL SCURVY IN THE NORTHERN STATES OF NIGERIA

INTRODUCTION

Almost from the onset of recorded nutritional disorders, scurvy has been a problem of man. The disease was observed to be common among the Roman Soldiers. Also with the start of long sea voyages, scurvy frequently broke out among the crew because fresh foodstuffs were not available.

Vasco Da Gama was reported to have lost as many as two-thirds of his crew as a result of scurvy outbreak. James Lind, a surgeon in the English Navy, had the genuis to observe, record and to conduct experiments with scurvy patients on board the H.M.S. Salisbury in 1947. His classical work led to the elimination of scurvy among the crews of ships (Stewart and Guthrie, 1953).

Scurvy is a nutritional disease caused by the deficiency of ascorbic acid. In man, scurvy occurs at any age and in both the sexes. Clinical symptoms in adults are however, different from those in infants and children. The symptoms in adults include swelling and bleeding of the gums, listlessness, weakness, bleeding under the skin, slow healing of wounds and bleeding of old wounds (Hodges et al. 1969; Baker et al. 1966; 1971). In children, clinical findings include failure to thrive,

irritability, anorexia, anaemia, haemorrhages and bone malformation which makes the disease look like rickets (Huisman and Jenxis, 1957; Cochrane, 1960).

Scurvy is a global problem and has been reported from everywhere (Wilson et al. 1965). In Nigeria, there is paucity of reports on scurvy although ascorbic acid values in some Nigerian fruits and vegetables have been reported (Reiff, 1959; Oke, 1967). The objective of the present study was to investigate the incidence of clinical scurvy among Nigerians of various ages.

MATERIALS AND METHODS

Survey areas

A total of forty-one medical centres were visited. They consisted of three hospitals attached to the Ahmadu Bello University, Institute of Health, two specialist hospitals, eleven government general hospitals, two military hospitals, seven private clinics, ten rural health centres and six maternity centres located in various parts of the country (Appendix 7).

Type of Medical Personnel Interviewed

During the scheduled visits 207 medical personnels concerned in the examination of, and prescription of medication to patients were interviewed for information on diagnosis and incidence of clinical scurvy.

RESULTS

In a total of 41 medical centres visited and the 207 medical personnel interviewed, there was no record of diagnosis of scurvy. Table (28) classifies the type of medical personnels interviewed. Since no-one reported ever diagnosing clinical scurvy, it was not necessary to go into the medical records of the various centres.

Only 2.41% reported that gingivitis was a common disorder in children during the dry season and responds very well to both ascorbic acid and penicillin therapy. 89.2% reported that they usually prescribed ascorbic acid to patients with common cold.

The results of an earlier study of selected population indicate an adequate intake of ascorbic acid during the dry and rainy seasons. Since this correlates well with the present

findings of no incidence of clinical scurvy, it was not considered necessary to analyse the blood samples of subjects studied for ascorbic acid content.

DISCUSSION

Scurvy which is an ascorbic acid deficiency has been reported (Grusinard, Kincard, Smith, 1954; Lind, 1960). Prevention of scurvy in man is by ingestion of a diet which supply more than 10mg ascorbic acid daily.

The present survey shows that classical scurvy is rahter unknown to us in Nigeria. Actual absence of scurvy could for now be spectulated. Clinical symptoms such as fever, cold and catarrh, ulcers, rickets and other forms of malnutrition such as nutritional anaemia, kwarshiokor and marasmus are all very common among Nigerians. Some of these symptoms are also characteristic of scorbutic patients. Because malaria, typhoid, influenza, kwarshiokor are very common, they may tend to preclude the likelihood of diagnosing scurvy whose symptoms to a large extent resemble those of other ailments.

No reports are available about the ascorbic acid status of Nigerians in health and disease. It is therefore suggested

that this area be investigated especially in cases of fever of unknown origin (FUO), slow wound healings, ulcers, gingivitis, ricket-like conditions and other bone problems, persistent haemorrhages and skin diseases. It is emphasised that the onset of scurvy is insiduous and clinical findings are non-specific.

SUMMARY

A total of 207 medical personnels consisting of medical officers, nursing sisters and suprintendents from 41 medical centres were interviewed for their experience with or incidence of scurvy in Nigeria.

No one reported ever seeing classical cases of scurvy since in practice. 2.41% reported that one common condition which responded to ascorbic acid therapy was gingivitis in children and 89.2% of those interviewed believed in prescription of ascorbic acid for the common cold.

It is not known if ascorbic acid deficiency in Nigerians manifests itself in another form or if there is no scurvy among Nigerians due to inadequate intake of ascorbic acid. The need for evaluation of ascorbic acid status of Nigerians in health and in disease is emphasized.

TABLE 33

TYPE OF PRACTICE OF MEDICAL PERSONNEL INTERVIEWED FOR INCIDENCE OF SCURVY

Medical Officers			Nursing Sisters		Nursing Suprintendents	
General Practice	Paedia-tricians	Medicine	Maternity Sisters	Health Sisters	General Nursing	Special Nursing
54	8	35	51	23	25	11

CHAPTER VIII

SEASONAL AVAILABILITY OF DIETARY ASCORBIC ACID (VITAMIN C) IN ZARIA DISTRICT OF KADUNA STATE, NIGERIA: GENERAL DISCUSSION AND CONCLUSION

Ascorbic acid is a water soluble vitamin which is multi-functional and is involved in many aspects of human physiology, some of which include collagen synthesis, reducing agent in biological system and the conversion of folic acid to folinic acid. Estimates of ascorbic acid requirements varies from 15mg in infants to 30mg in the aged. In fact careful experimental work indicates that 10mg daily is sufficient to prevent scurvy and maintain good healing properties of tissues. Ascorbic acid is widely distributed in fruits and vegetable.

The assessment of the nutritional status of any community is best done by evaluating the nutrient content of foodstuff actually eaten, measuring of biochemical parameters which indicate marginal nutrition and identifying specific symptoms associated with deficiency diseases. In addition it is desirable to investigate the climate, food production and supply and other socio-economic factors of the community studied in order to give a meaningful explanation to some phenomenon observed in food intake.

The use of food composition tables in evaluating ascorbic acid content of foodstuffs should be limited since values obtained by this method do not take into consideration variations which might be due to genetic constitutions, soil and climatic

conditions and methods of preparation. The studies presented here and the work of others however, show that chemical analysis of foodstuff for ascorbic acid gives a more accurate information on the ascorbic acid nutrition of a community.

Citrus fruits are good sources of ascorbic acid but because they do not thrive in the area of study their use as a source of ascorbic acid is very limited. However, the bulk of the ascorbic acid in the diet is produced by leafy vegetables and dry season fruits such as sugar cane, carrots and mangoes. Within the rural population baobab leaves and soured milk "none" provide adequate ascorbic acid all year round.

The practice of dry season farming has reduced the seasonal fluctuations in vegetable production only to an unappreciable extent. The absence of any significant difference in the ascorbic acid content of vegetables grown during the dry and rainy season is an indication that the production of dry season vegetables would augment the ascorbic acid intake during this period. As a result of this investigation the following conclusions have been made:

CONCLUSIONS

1. The diet of rural, sub-urban and urban populations of survey area provide adequate ascorbic acid all year round.
2. Vegetables constitute the largest common source of ascorbic acid owing to seasonal availability and hence the very low consumption of fruits.
3. The mean ascorbic acid intake of children two to four years old was 34.69mg/day during the dry season and 48.62mg/day during rainy season.
4. The mean ascorbic acid intake of children five to seven years old was 46.91mg/day during dry season and 64.76mg/day during rainy season.
5. The mean ascorbic acid intake of old people aged 55 to 72 years was 37.98mg/day during dry season and 51.93mg/day during rainy season.
6. Ascorbic acid intake was significantly ($P < 0.05$) affected by season and location. Maximum amount of ascorbic acid (98.97mg/day) was consumed by rural children during rainy season and minimum (24.05mg/day) by urban old people during dry season.

7. Dry season farming increased fresh vegetable supply during the dry season although the prices are repelling and therefore only high income earners can afford to use them at that time.

8. Plasma ascorbic acid level of six adult volunteers on regular diet ranged from 0.63 to 1.14 mg%, urinary ascorbic acid excretion in the same subjects also ranged from 31.3 to 106.4mg/g creatinine. Treatment of subjects with 60mg ascorbic acid from "kuka" soup or ascorbic acid tablet increased plasma ascorbic acid by 35.9 and 91.0 per cent respectively. Urinary ascorbic acid excretion was also increased.

9. Availability of ascorbic acid from "kuka" soup was about 40% compared with that of tablet as judged from changes in blood level with subjects not deficient in ascorbic acid intake.

10. Content of ascorbic acid and moisture were higher in vegetables produced during rainy season than in the same vegetables produced during the dry season by irrigation. The difference was significant ($P < 0.05$) in red peppers and okro.

11. The traditional method of boiling vegetables in slight excess of water leads to ascorbic acid loss ranging from 39 to 78 per cent. Ascorbic acid loss due to cooking of the vegetables into soup ranged from 66.2% in "kuka" to 94.6% in stew. Storage and reheating of the soups decreased their ascorbic acid content.

12. Sun-drying followed by storage of vegetables at room temperature for six months reduced ascorbic acid by 42 to 61 per cent.

13. Clinical scurvy does not apparently exist in the Northern States of Nigeria although a non-scorbutic deficiency-gingivitis occurs in children during the dry season.

SUGGESTIONS FOR FURTHER STUDIES

1. The nutritional survey on the seasonal ascorbic acid intake should be expanded to cover all Nigeria and a wider range of population.
2. Determine the uptake of ascorbic acid from "kalkashi", okro, sorrell soups and compare to that already established for "kuka" soup since these vegetables contribute high ascorbic acid to the diet of the population studied.
3. Investigate the properties of the mucilagenous substance formed during the extraction procedure of okro, "kalkashi", ayoyo and baobab leaves and its effect on the uptake of ascorbic acid in the diet.
4. Investigate the nature of the products formed during browning of vegetables, in storage and possibly how they affect ascorbic acid loss.
5. Investigate ascorbic acid status of Nigerians in health and disease.

REFERENCES

Abbassy, M. A.; Harris, L. J. and Ellman, P. (1937): Vitamin C and infection, excretion of vitamin C in pulmonary tuberculosis and in rheumatoid arthritis, Lancet 2: 181-183.

Abt, A. F.; Vaon Schuchhing, S. and Roe, J. H. (1960): Connective tissue studies III. Ascorbic acid, collagen and hexosamine distribution and histology of connective tissues. Scars produced in guinea pigs on various vitamin C dietary levels following wounding by abdominal incission. J. Nutr. 70: 427-437.

Addo, A. A. (1973): Effect of cooking on ascorbic acid retention and palatability of frozen okra. M.S. thesis, Kansas State University, U.S.A.

Alder, N. (1957): Observation in blood ascorbic acid in old age. Nutr. 11: 173-174.

American Academy of Pediatrics, Committee on Nutrition (1962): Infantile scurvy and nutritional rickets in the United States. Paediat. 29: 646-647.

Andrews, J. and Brook, M. (1966): Leucocyte vitamin C content and clinical signs in the elderly. Lancet 1: 1350-1351.

Andrews, J; Letcher, M. and Brook, M. (1968): Vitamin C supplementation in the elderly. A 17-month trial in an old person's home. Brit. Med. J., 2: 416-418.

Andrews, J. and Brook, M. (1969): Vitamin C and the elderly. Brit. Med. J. 3: 176.

A. O. A. C. (Association of Official Analytical Chemists) (1975): Official methods of analysis (Ed.) William Horwitz.

Apte, S. V. and Venkatachalam, P. S. (1965): The effect of ascorbic acid on the absorption of iron.. Ind. J. Med. Res. 53: 1054-1056.

Atkins, G. L.; Dean, B. M.; Griffen, W. J. and Watts, R. W. E. (1964): Quantitative aspects of ascorbic acid metabolism in man. J. Biochem. 239: 2975-2980.

Augustin, J., McDole, R. E.; MacMaster, G. M.; Painter, C. G. and Sparks, W. C. (1975): Ascorbic acid content in Russet Burbank potatoes, J. Fd. Sci., 40: 415-416.

Bailey, D. A.; Carron, A. V.; Teece, R. G. and Wehner, H. J. (1970): Vitamin C supplementation related to physiological response to exercise in smoking and non-smonking subjects. Am. J. Clin. Nutr. 23: 905-912.

Baker, E. M.; Saari, J. C. and Tolbert, B. M. (1966): Ascorbic acid metabolism in man. Am. J. Clin. Nutr. 19: 371-378.

Baker, E. M.; Hodges, R. E.; Hood, M. D.; Sauberlich, H.E.; March, S. C. and Canham, J. E. (1971): Metabolism of 14C and 3H-labelled L-ascorbic acid in human scurvy. Am. J. Clin. Nutr. 24: 444-454.

Banay, M. and Dimat, E. (1962): On the metabolism of L-ascorbic acid in the scorbutic guinea pig. Biochem. Biophys. Acta., 59: 313-319.

Banerjee, S. and Singh, H. D. (1958): Cholesterol metabolism in scorbutic guinea pigs. J. Biol. Chem., 2: 336-339.

Bangerth, F. (1973): Effect of low pressure storage on the physiology, quality and storage life of fruit, vegetables and cut flowers. Gartenbanwissen Scaft, 38: 479-508.

Barakat, M. Z.; El-Wahab, M. F. and El-Sadr, M. M. (1955): Action of N-bromosuccinimide on ascorbic acid. New method for estimation of vitamin C. Anal. Chem., 27: 536-540.

Barakat, M. Z. and Abdalla, A. (1965): Ascorbic acid content of edible liver. J. Fd. Sci., 30: 185-187.

Bassir, O. (1953): Nutrition in Nigeria. W. Afr. Med. J., 2: 30-41.

Bassir, O. (1965): Problems of human nutrition in Nigeria. W. Afr. Med. J., 14: 54-68.

Beastle, G. (1974): Antioxidant action of ascorbic acid in beer. Fermentation., 70: 38.

Beaton, G. H.; Hellburst, D.M.; Paul, W. and Wright, A. M. (1960): The effect of scurvy on thyroid activity in the guinea pig. J. Nutr. 70: 321-351.

Bender, A. E. (1967): Dietetic Foods. Leonard Hill Books, London, 217.

Berry, R. E. and Tatum, J. H. (1965): 5-hydroxy methylyfurfural in stored foam-mat orange powders. J. Agric. Fd. Chem. 13: 588-590.

Bolin, H. R. and Stafford, A. E. (1974): Effect of processing and storage on provitamin A and vitamin C in apricots. J. Fd. Sci., 39: 1034-1036.

Bolomey, R. A. and Kemmener, A. R. (1946): The determination of ascorbic acid, a simplification of the Roe method. J. Biol. Chem., 165: 377-378.

Bolemey, R. A. and Kemmener, A. R. (1947): Spectrophotometric studies of the Roe's method for the determination of dehydro-ascorbic acid. J. Biol. Chem., 167: 781-785.

Bourquinn, A. and Musmanno, E. (1953): Preliminary report on the effect of smoking on the ascorbic acid content of whole blood. Am. J. Digest. Dis., 20: 75-77.

Boyle, P. E. and Irving, J. T. (1951): Skeletal muscle changes in scurvy with note on mechanisms of attachment of myofibrils to tendon. Science. 114: 572-573.

Brin, M.; Dibble, M. V.; Peel, A.; McMullen, E.; Bourquin, A. and Chen, N. (1965): Some preliminary findings on the nutritional status of the aged on Onondaga county, New York. Am. J. Clin. Nutr., 17: 240-258.

Brise, H. and Hallberg, L. (1962): Effect of ascorbic acid on iron absorption. Acta. Med. Scand. Suppl., 51: 59-73.

Brocklehurst, J. C.; Griffiths, L. L., Taylor, G. F.; Marks, J.; Scott, D. L. and Blackley, J. (1968): The clinical features of chronic vitamin deficiency. A therapeutic trial in a geriatric hospital patients. Geront. Clin. 10: 309-320.

Brook, M. and Grimshaw, J. J. (1968): Vitamin C concentration of plasma and leucocytes as related to smoking habits, age and sex of humans. Am. J. Clin. Nutr.., 21: 1254-1258.

Brown, A. (1955): Megaloblastic anaemia associated with adult Scurvy. Report of a case which responded to synthetic ascorbic acid alone. Brit. J. Haematol. 1: 345-351.

Burch, H. B. (1961): Methods of detecting and evaluating ascorbic acid deficiency in man and animal. Ann. N. Y. Acad. Sci. 92: 268-276.

Burns, J. J.; Kanfer, J. and Dayton, P. G. (1958): Metabolism of L-ascorbic acid in rat kidney. J. Biochem. 232: 107-115.

Burlina, A. (1956): Vitamin C metabolism in old age. Acta Gerontol. 6: 71-79.

Calder, J. H.; Curtis, R. C. and Fore, H. (1963): Comparison of vitamin C in plasma and leucocytes of smokers and non-smokers. Lancet. 9: 556.

Caldwell, M. and Guin-Sai, Y. (1973): The effect of cooking method and storage on the ascorbic acid content of Malaysian leaf vegetables. Ecol. Fd. Nutr . 2: 35-38.

Chan, P. C.; Becker, R. R. and King, C. G. J. (1958): Metabolic products of L-ascorbic acid. J. Biochem. 221: 231-240.

Chartres, J. C. (1951): Medical Field Units, Nigeria: their function and work. Brit. Med. J. 1: 85-88.

Chelkowski, J. and Brelinski, B. (1974): Fluorescence method for the determination of vitamin C content of foods and natural raw materials. Przensyl Spozywczy, 28: 66-68.

Cochrane, W. A. (1960): Infantile scurvy. Brit. Med. J. 1: 1567.

Cohen, M. M. and Duncan, A. M. (1967): Ascorbic acid nutrition in gastroduodenaldisorders. Brit. Med. J. 4: 516-518.

Collins, M. and Elvehjem, C. A. (1959): Ascorbic acid requirement of the guinea pig using growth and tissue ascorbic acid concentration as criteria. J. Nutr. 64: 503-511.

Collis, W. R. F.; Dema, I. S. and Lesi, F. E. A. (1962): Transverse survey of health and nutrition, Pankshin Division, Northern Nigeria. W. Afr. Med. J. 11: 131-134.

Collis, W. R. F.; Dema, I. S. and Omololu, A. (1962): On the ecology of child nutrition in Nigerian villages. Top. Geogr. Med. 14: 14?-2?1.

Coward, K. H. (1947): Biological Standardization of the vitamins. Bailliere, Tindall and Cox. London 2nd ed. 93.

Crampton, E. W.; Collier, B. C.; Woolsey, L. D. and Farmer, F. A. (1944): A new procedure for the bioassay of vitamin C. Science. 100: 599-60?.

Dallyn, M. H. and Moschette, D. S. (1952): Ascorbic acid nutrition of children. J. Am. Dietet. Assoc. 28: 718-722.

Davey, B. L.; Wu, M. L. and Storvick, C. A. (1952): Daily determination of plasma serum and white cell platelet ascorbic acid in relationship to excretion of ascorbic and homogentisic acids by adults maintained on controlled diet. J. Nutr. 47: 341-351.

Davidek, J., Velisek, J. and Janicek, G. (1974): The stability of vitamin C in orange drink. Lebensmittle-Wissen Schaft. Technologie. 7: 285-287.

Davidek, J.; Velisek, J. and Nozbedova, M. (1971): Determination of dehydroascorbic acid in meat and meat products. Sbornik Vysoke Skoly Chemicko-Technologicke V Praze E. no. 30: 17-23. Abstracted from Chem. Abstracts 4 (1974).

Davidek, J., Brendl, J., Kyzlink, V and Klein, S. (1971): Ascorbinsuare in Fleisch und un den Fleischproduckten. Bedingungen zur poplargraphischen Bestimming von L-ascorhimund, L-dehydroascorbinasure Sbornuk Vysoke Skoly Chemicko-Technologicke V Praze E. no. 32: 161-171. Abstracted from Food Science and Technology Abstracts 7 (1976).

Davidek, J., Velisek, J. and Domah, A. M. B. (1974): Determination of L-ascorbic acid and L-dehydroascorbic acid in potatoes. Zeitschrift Fur LebenSmittle-Unter-Suchung und Forschung 154: 18-22. Abstracted from Food Science and Technology Abstract 7 (1976.

Dema, I. S. (1965): Nutrition in relation to Agricultural production. F. A. O., Rome, 2965.

Diehl, H. S. (1971): Vitamin C for colds. Am. J. Pub. Hlth. 61: 649-651.

Disselduff, M. M. and Murphy, E. Lac (1968): Vitamins in the elderly. ed. A. N. Exton-Smith and D. L. Scott. Bristol J. Wright and Sons Ltd; 60.

Dodds, M. L. (1969): Sex as a factor in blood levels of ascorbic acid. J. Am. Dietet. Ass. 54: 32-33.

Domah, A. A. M. B.; Davidek, J. and Velisek, J. (1974): Changes of L-ascorbic and L-dehydroascorbic acid during cooking and frying of potatoes. Zeitschrift Fur Lebensmittel-Untersuchung Und-Forschung 154: 270-272. Abstracted from Food Science and Technology Abstracts Vol. 1-5 (1975).

Dubasova, E. P. (1971): Soderzaine vitaminor Ci P. V Krovi i Moce detey pri zabole vanija pocek Vop Ohrang Mater Det. 16: 29-33. Abstracted from Food Science and Technology Abstract Vol. 1-5 (1975).

Dustin, J. P. and Bigwood, E. J. (1953): Aminoaciduria in infancy and ascorbic acid deficiency. Proc. Nutri. Soc. (Engl. and Scot) 12: 293-300.

Dymock, S. M. and Brocklehurst, J. C. (1973): Clinical effects of water soluble vitamin supplementation in geriatric patients. Age and Ageing, 2: 172-176.

Edozien, J., Phillips, E. and Collis, W. (1960): The free amino acids of plasma and urine in kwashiokor. Lancet. 1: 615-616.

Eheart, M. S. (1967): Effect of microwave versus water blanching on nutrients in broccoli; chlorophylls, ascorbic acid, pH and total acids. J. Am. Dietet. Assoc. 50: 207-212.

Evered, D. F. (1960): Determination of ascorbic acid in highly coloured solutions with N-bromossucinimide. Analyst 85: 515-517.

Exton-Smith, A. N. (1970): Nutrition surveys and the problems of detection of malnutrition in the elderly. Nutrition, 24: 218-223.

Follis, R. H. Jr. (1958): Deficiency Diseases. Charles C. Thomas Publishers, Springfield, Illinois, U.S.A. 2nd ed. pp. 175-184.

Food and Agriculture Organisation of the United Nations and United States Department of Health, Education and Welfare (1968). Food composition table for use in Africa.

Fullmer, H. M.; Martins, G. R. and Burns, J. J. (1961): Role of ascorbic acid in the formation and maintenance of dental structures. Ann. N. Y. Acad. Sci., 92: 286-294.

Gibson, M., Moore, F. M. L. and Goldberg, A. (1969): Measurement of leucocyte ascorbic acid. Brit. Med. J., 1: 1152-1153.

Ginter, E., Babala, J. and Cerven, J. (1969): The effect of chronic hypovitaminosis C on the metabolism of cholesterol and artherogenesis in guine pigs. J. Arthero. Res. 10: 341-352.

Ginter, E., Nemec, R. and Bobek, P. (1972): Stimulation of (26-14C) cholesterol oxidation by ascorbic acid in scorbutic guinea pigs. Brit. J. Nutr. 28: 205-211.

Ginter, E., Cerven, J., Nemec, R. and Mikins, L. (1974): Lowered cholesterol catabolism in guinea pigs with chronic ascorbic acid deficiency. Am. J. Clin. Nutr. 24: 1238-1245.

Ginter, E. (1975): The part played by ascorbic acid in cholesterol metabolism. Vopr. Pitniia, 31: 25.

Giri, K. V. and Doctor, N. S. (1938): Pyrophosphate in the determination of vitamin C of plant and animal tissues. Ind. J. Med. Res. 26: 165-170.

Goldberg, A. (1963): The anaemia of scurvy. Quart. J. Med. 32: 51-64.

Gottileb, A. A., Kaplan, A. and Underfriend, S. (1966): Further evidence for the accumulation of a hydroxyproline deficient collagenase-degradable protein during collagen biosynthesis in vitro. J. Biochem. 241: 1551-1555.

Griffiths, L. L., Brocklehurst, J. C., MaClean, R. and Fry, J. (1966): Diet in old age. Brit. Med. J. 1: 739.

Griffiths, L. L., Brocklehurst, J. C., Scott, D. L., Marks, J. and Blackley, J. (1967): Thiamine and ascorbic acid levels in the elderly. Geront. Clin., 9: 1-10.

Grusin, H. and Kincaid-Smith, P. S. (1954): Scurvy in adult Africans. A clinical haematological, and pathological study. Am. J. Clin. Nutr. 2: 323-335.

Harris, L. J. and Oliver, M. (1942): Vitamin methods. The reliability of the method for estimating vitamin C by titration against 2, 6, dichlorophenolindophenol. Control tests with plant tissues. J. Biochem. 36: 155-182.

Harris, L. J., Constable, B. J., Hughes, R. E. and Loewi, G. (1955): Influence of cortisone on ascorbic acid requirement of guinea-pigs, an assessment by the tooth structure method. Brit. J. Nutr. 9: 310-316.

Hellman, L. and Burns, J. J. (1958): Metabolism of L-ascorbic acid-1-C14 in man. J. Biochem. 230: 923-930.

Henley, E. D., Christenhouse, W. N., Grace, W. J., Wolff, H. G. and Steinhouse, D. (1956): Absorption of iron from the gastro-intestinal tract. A comparative test in human beings using stable and radioactive iron. Am. J. Clin. Nutr. 4: 609-618.

Herrmann, K., Thumann, T., Suter, G. and Nobe, G. (1973): Effect of cooking method on ascorbic acid content of Kohlrabi brussel sprouts, cauliflower, beans and potatoes. Ernahrungs-Umschau 20: 438-440. Abstracted from Food Science and Technology Abstracts 6 (1975).

Herrman, K., Nebe, G. and Suter, G. (1974): The disadvantages of keeping cooked vegetables hot. Ascorbic acid losses during keeping hot, during cold storage for short periods and during rewarming. Ernahrungs-Umschau 21: 109-112. Abstracted from Food Science and Technology Abstracts 7 (1976).

Hill, C. R. and Bourne, G. H. (1958): Histochemical changes in organs and tissues of Scorbutic guinea pigs. Brit. J. Nutr. 12: 237-253.

Hodges, R. E., Baker, E. M., Hood, J., Sauberlich, H. E. and March, S. C. (1969): Experimental scurvy in man. Am. J. Clin. Nutr. 22: 535-548.

Hodges, R. E. (1971): What's new about scurvy? Am. J. Clin. Nutr. 24: 383-384.

Holst, A. and Frolich, T. (1912): Ueber experimentellen skorbut Ein Beitrang zur Lehre von dem Einfluss einer einseitgen Nahrung. Z. Hyg. Infektionskrankh. 72: 1-120. Abstracted from (Nutr. Abstracts and reviews). Human Scurvy HAB No. 23 An annotated bibliography from the Commonwealth Bureaux of Nutrition Published in 1973.

Hudson, M. A., Sharpels, V. T., Pickford, E. and Leach, M. (1974): Quality of home frozen vegetables. Effect of blanching and/or cooking in various solutions on organoleptic assessment and vitamin C content. J. Fd. Technol. 9: 95-103.

Huisman, T. H. J. and Jonxis, J. H. P. (1957): Some investigations on the metabolism of phnyl-alanine and tyrosine in children with vitamin C deficiency. Arch. Dis. Child. 32: 77-81.

Idusogie, E. O. (1971): The nutritional requirements of the Nigerian populations. Afr. J. Med. Sci. 3: 53-56.

Inter-departmental Committee on Nutrition for National Development (ICNND) (1967): Report of the nutrition survey of the Republic of Nigeria, February-April, 1965. Nutrition section of International Research, National Institute of Health, Bethesday, U. S. A.

Jedrzejezyk, H. (1974): Preservation of vitamin C in Saukerat during production, storage and distribution. Przemyel Fermentiacyjnji Rolyn. 18: 12-15

Joffee, N. (1961): Some radiological aspects of scurvy in the adult. Brit. J. Radiol. 34: 429-437.

Jonxis, J. H. P. and Wadman, S. K. (1951): De witscheidung van aminozuren un de urine bi, een patient met Scorbulit. Maandsclar, Kindergeneesk. 18: 251-258. Abstracted from Human Scurvy; HAB No. 23 Commonwealth Bureau of Nutrition 1974.

Joslyn, A. (1970): Methods in Food analysis, physical, chemical and instrumental methods of analysis. Academic Press, New York. 2nd ed.

Juergen, D. (1968): Thin layer chromatography of carboxylic acids on cellulose. J. Chromatogr. 34: 407-410.

Kajita, T. Yamamoto, Y. and Senda, M. (1973): Determination of L-ascorbic acids in foods by the polarographic O-phenylenediamine method. Jap. Anal. 22: 1051-1057.

Kefford, J. F., MacKenzie, H. A. and Thompson, C. O. (1959): Effects of oxygen on quality and ascorbic acid retention in canned and frozen orange juices. J. Sci. Fd. Agric. 10: 51-63.

Ketz, H. A. (1970): Uber die prophylaktishe wirking des vitamin C und den vitamin C Badarf des gesunden Erwachsenen. Deutsch Gesundheitswesen. 25: 414-417. Abstracted from Food Science and Technology 6 (1975).

Kim, S. D., Choi, J. U. and Sohn, T. H. (1973): A study on the storage of fresh fruits and vegetables. Effect of controlled atmospheric pressure on the storage of tomato fruits. J. Kor. Agri. Chem. Soc. 16: 94-98.

Kitabchi, A. F. (1967): Ascorbic acid in steroidogenesis. Nature (London) 215: 1385-1386.

Kitagawa, Y. (1973a): Distribution of vitamin C related to growth of some fruits, tomato, pimento and strawberry. J. Jap. Soc. Fd. Nutr. 26: 139-143.

Kitagawa, Y. (1973b): Distribution of vitamin C in relation to the growth of edible vegetables. J. Jap. Soc. Fd. Nutr. 26: 551-557.

Knox, W. E. (1955): The metabolism of phenylalanine and tyrosine. In: Symposium on amino acid metabolism (W. D. McElroy and H. B. Glass editors). John Hopkins Press, Baltimore, Maryland. 836-866.

Knox, W. E. and Goswami, M. N. D. (1961): Ascorbic acid in man and animals. In: Advances in Clinical Chemistry edited by Sobotka, H. and Stewart, C. P. 4: 121-205.

Kotnis, M. and Houssain, M. A. (1974): Estimated intake of calories and nutrients in relation to recommended allowances UNICEF Fellows Report of Igbo-Ora Survey. University of Ibadan Press., p. 6.

Lamden, M. P. and Harris, R. S. (1950): Browning of ascorbic acid in pure solutions. Fd. Res. 15: 79-89.

Lind, T. (1960): Adult Skorbut. Kliniska och hematologiska aspekter. Nord. Med. 63: 575-579. Abstracted from Human Scurvy, Commonwealth Bureau of Nutrition, 1974.

Lloyd, B. B. and Sinclair, H. M. (1953): Vitamin C. In: Biochemistry and Physiology of Nutrition (G. H. Bourne and G. W. Kidder editors). Acad. Press, New York. 1: 369-471.

Lowry, O. H., Lopez, J. A. and Bessey, O. A. (1945): The determination of ascorbic acid in small amounts of blood serum. J. Biochem. 160: 609.

Maclean, H. E., Dodds, P. M., Stewart, A. W., Beaven, D. W. and Riley, C. G. (1976): Nutrition of elderly men living alone. Part II. Vitamin C and thiamine Status. New-Zealand Med. J. 84: 345-348.

Mangalam, N. and Mudambi, S. R. (1972): Market survey of fruits and vegetables for ascorbic acid content. Ind. Fd. Pack. 20: 20-22.

Mannering, G. J. (1949): Vitamin requirements of the guinea pig. Vit. and Horm. 7: 201-221.

Markakis, P., Malewski, W., Pantos, C. E. and Boloorforoosham, M. (1974): The ascorbic acid contents of tomatoes, ripened on or off the vine. (Conference proceedings in International Congress of Food Science and Technology, Ia, 92).

Marks, J. (1968): The vitamins in helath and disease. A modern re-appraisal. J. & A. Churchill Ltd; London. 2nd edition.

Mascitelli, C. E. and Maiocchi, G. (1954): Altivta del tiouracil e della vitamina C su cavie normali e scorbutiche trixinizzate. Arch. Farmacol. Sper. 82: 1-5. Abstracted from Human Scurvy. Commonwealth Bureau of Nutrition 1974.

Merck Service Bulletin (1956): Vitamin C. Merck and Co. Inc. Railway. New Jersey.

Meyer, K. H., Haselbach, C. H. and Boissomas, R. A. (1952): Dosage rapide de l'acide ascorbique des surrenales de rat. Helu Chem. Acta. 35: 1781-1783. Abstracted from Human Scurvy. Commonwealth Bureau of Nutrition, 1974.

Miers, J. C., Wong, F. F., Harris, J. G. and Dietrich, W. C. (1958): Factors affecting storage stability of spray-dried tomato powder. Fd. Tech. 12: 542-548.

Mikhailov, V. (1974): Storage of water melons and melons in the Crimea. Kartofel i Ovoschichi, 11: 36-37. Abstracted from Food Science and Technology Abstracts 7 (1976).

Milne, J. S., Lonergan, M. E., williamson, J., Moore, F. M. L., McMaster, R. and Percy, N. (1971): Leucocyte ascorbic acid levels and vitamin C intake in older people. Brit. Med. J. 4: 383-386.

Moser, E., Sunn, H. J. and Bieler, F. (1974): Effect of transport and intermediate storage in large containers on the quality of black currants. Erwerbsobstbau, 16: 53-56. Abstracted from Food Science and Technology Abstracts 7 (1976).

Morgan, A. F., Gullum , A. I. and Williams, R. I. (1955): Nutritional status of ageing serum ascorbic acid and intake. J. Nutr. 55: 431-448.

Myasnikov, A. L. (1958): Influence of some factors on development of experimental cholesterol atherosclerosis. Circ. 17: 99-113.

Nagy, S. and Snoot, J. M. (1977): Temperature and storage effects on per cent retention and per cent U. S. Recommended Dietary Allowance of vitamin C in canned single-strength orange juice. J. Agric. Fd. Chem. 25: 135-138.

Nakamura, M., Kawagoe, T., Oguine, Y., Nishiyama, K., Ichikawa, H. and Sugahara, K. (1967): Experimental study on the effect of vitamin C on the basal metabolism and resistance to common cold in human beings. Tohoku J. Exp. Med. 92: 207-219.

Nambisan, B. and Kurup, P. A. (1975): Ascorbic acid and glycosaminoglycan and lipid metabolism in guinea pigs fed normal and atherogenic diets. Athero. 22: 447-461.

Neilson, J. M. (1960): Megaloblastic anaemia in Scurvy: Report of a case. Scot. Med. J. 5: 42-44.

Nicol, B. M. (1956a): The nutrition of Nigerian children with particular reference to their energy requirements. Brit. J. Nutr. 10: 181-197.

Nicol, B. M. (1956b): The nutrition of Nigerian children with particular reference to their ascorbic acid requirement. Brit. J. Nutr. 10: 275-285.

Nicol, B. M. (1958): The ascorbic acid in the diets of rural Nigerian Peoples. W. A. M. J. 7: 185-189.

Noble, I. and Gordon, J. (1964): Effect of blanching method on ascorbic acid and colour of frozen vegetables. J. Am. Dietet. Assoc. 44: 120.

Nungester, W. J. and Ames, A. M. (1948): Relationship between ascorbic acid and phagocytic activity. J. Inf. Dis. 83: 50-54.

Nutrition Canada Eskimos Survery (1975): Bureau of Nutritional Sciences, Department of National Health and Welfare.

Ogbeide, O. (1974): Nutritional hazards of food taboos and preferences in Mid-West Africa. Am. J. Clin. Nutr. 27: 213.

Ogunmodede, B. K. (1975): Ascorbic acid in some orange varieties grown in Nigeria. Paper presented at the 1st African Nutrition Congress. University of Ibadan, Nigeria. 16th-21st March, 1975.

Oke, O. L. (1966a): The ascorbic acid content of some animal organs. Nutrition (London). 20: 110-112.

Oke, O. L. (1966b): The ascorbic acid content of Nigerian foodstuffs. W. Afr. Pharm. 8: 92-93.

Oke, O. L. (1967): The ascorbic acid contents of Nigerian vegetables. J. Food Sci. 32: 85-86.

Oluwole, Y. O. and Adedipe, N. O. (1978): Some storage characteristics of two Nigerian leafy vegetables. (Amaranthus Candatus and Celosea argenta). Bull. Sci. Assoc. Nigeria. 4: 9.

Omololu, A. (1972): Nutrition and the African Child. J. Trop. Ped. and Env. Ch. He. 18: 144-149.

Osifo, B. O. A. (1970): The effect of diet on the haemoglobin and haematocrit values of some Nigerian village children. Brit. J. Nutr. 24: 683-688.

Pauling, L. (1970): Vitamin C and the cold. W. H. Freeman and Co., 1970; San Francisco, U.S.A.

Petrovic, S. E., Belia, B. E. and Vukajlovic, D. (1968): Separation of water soluble vitamins on starch thin layers. Anal. Chem. 40: 1007-1008.

Pelletier, O. (1968): Smoking and vitamin C levels in humans. Am. J. Clin. Nutr. 21: 1259-1267.

Pelletier, O. (1970): Vitamin C status of cigarette smokers and non-smokers. Am. J. Clin. Nutr. 23: 520-524.

Pfander, W. H. (1952): The effects of iodinated casein, thiouracil and cortisone on the ascorbic acid requirement of the male guinea pig. J. Nutr. 47: 487-501.

Platt, B. S. (1945): Tables of representative values of foods commonly used in tropical countries. Medical Research Council, Special Report Series no. 253. Her Majesty Stationery Office, London.

Ranganathan, S. (1942): The vitamin C content of some dehydrated vegetables and fruits and of fruit juice preparation. Ind. J. Med. Res. 30: 517-528.

Ramasastri, B. V. (1974): Effect of storage on the ascorbic acid content of dehydrated amla (Emblica officinalies) powder. Ind. J. Nutr. Dietet. 11: 134-136.

Reid, M. E. (1948): Urinary excretion of ascorbic acid by guinea pigs at different ages. J. Nutr. 35: 619-627.

Reiff, B. (1959): Plasma and urinary vitamin C level in adult Nigerians with a note on the ascorbic acid content of some Nigerian Foodstuffs. W. Afr. Med. J. 8: 149-151.

Riemer, J. and Karel, M. (1978): On the anaerobic degradation of ascorbic acid in dehydrated tomato juice. Agric. Food Chem. 26: 350-353.

Robertson, W., Van B. and Hewilt, J. (1961): Augmentation of collagen synthesis by ascorbic acid in vitro. Biochem. Biophys. Acta. 49: 404-406.

Robinson, W. B. and Stotz, E. J. (1945): The indophenol xylene extraction method for ascorbic acid and modification for interference. J. Biol. Chem. 160: 217.

Roe, J. H. and Keuther, C. A. (1943): The determination of ascorbic acid in whole blood and urine through the 2, 4, dinitrophenylhydrazine derivative of dehydroascorbic acid. J. Biochem. 147: 399.

Roine, P., Koivula, L., Pekkarinen, M. and Rissanen, A. (1974): Vitamin C intake and plasma level among aged people in Finland. Int. J. Vit. Nutr. Res. 44: 95-106.

Russel, R. I., Goldberg, A., Williamson, J. M. and Wanes, E. (1968): Ascorbic acid levels in leucocytes of patients with gastrointestinal haemorrhage. Lancet. 2: 603-608.

Sabry, J. H., Fisher, K. H. and Dodds, M. L. (1958): Human utilization of dehydroascorbic acid. J. Nutr. 64: 457-466.

Salomon, L. L. and Stubbs, D. W. (1961): Some aspects of the metabolism of ascorbic acid in rats. Ann. N. Y. Acad. Sci. 92: 128-140.

Salmon, R. J. and May, C. D. (1952): Total plasma protein and plasma fabrinogen in ascorbic acid deficiency and in scurvy in monkey. J. Nutr. 46: 515-523.

Schaffert, R. R. and Kingsley, G. R. (1955): A rapid simple method for the determination of reduced dehydro and total ascorbic acid in biological material. J. Biochem. 212: 59.

Schans, R. (1957): The ascorbic acid content of human pituitary, cerebral cortex, heart and skeletal muscle and its relation to age. Am. J. Clin. Nutr. 5: 39-41.

Schlack, J. E. (1974): Quantitative determination of L-ascorbic acid by gas-liquid chromatography. J. Assoc. Off. Analyt. Chem. 57: 1346-1348.

Snedecor, G. W. and Cochran, W. G. (1971): Statistical Methods. 6th edition. The Iowa State University Press. Ames, Iowa, U. S. A., 91-119.

Sobotka, H. and Stewart, C. P. (1961): Ascorbic acid distribution in normal guinea pigs. In: Advances in Clinical Chemistry. 4: 148.

Sokoloff, B., Hori, M., Saelhof, C. C., Wrzolek, T. and Ima, F. (1966): Ageing artherosclerosis and ascorbic acid metabolism. J. Amer. Geriat. Soc. 14: 1239-1260.

Sood, R. and Bhat, C. M. (1974): Changes in ascorbic acid and carotene content of green vegetables on cooking. J. Fd. Sci. Technol. Ind. 11: 131-133.

Spathis, G. S. and Hallpike, J. F. (1961): Observations upon the distribution of ascorbic acid in human blood. Guy's Hosp. Re. 110: 148-156.

Steele, B. F., Hsu, C., Pierce, Z. H. and Williams, H. H. (1952): Ascorbic acid nutriture in the humans. Tyrosine metabolism and blood levels of ascorbic acid during ascorbic acid depletion and repletion. J. Nutr. 48: 49-59.

Stewart, C. P. and Guthrie, D. (1953): Lind's Treatise on Scurvy. A bicentenary volume with additional notes. University Press, Edinburgh, Scotland.

Stone, M. and Meister, A. (1962): Function of ascorbic acid in the conversion of proline to collagen hydroxyproline. Nature. 194: 555-557.

Srikantia, S. G., Mohanram, M. and Krishmswamy, K. (1970): Human requirements of ascorbic acid. Am. J. Clin. Nutr. 23: 59-62.

Takama, F., Fukuda, S., Toyomaki, Y., Toyomaki, K. and Santo, S. (1973): Changes in the chemical components of cucumber and sweet pepper fruits during growth. J. Jap. Soc. Fd. Nutr. 26: 329-332.

Tatum, J. H., Shaw, P. E. and Berry, R. E. (1967): Some compounds formed during non-enzymic browning of orange powder. J. Agric. Fd. Chem. 15: 773-775.

Taussky, H. H. (1954): Microcolorimetric determination of creatinine in urine by Jaffe reaction. J. Biol. Chem. 208: 853-861.

Taylor, O., Fetuga, B. L., Olubajo, F. O. and Oyenuga, V. A. (1975): The ascorbic acid contents of three Nigerian leafy vegetables as affected by age and nitrogen fertilization. Paper presented at the 1st African Nutritional Congress. University of Ibadan, Ibadan, Nigeria. 16th-21st March, 1975.

Thomas, P. (1975): Effect of post-harvest temperature on quality of carotenoids and ascorbic acid content of Alphonso mangoes on ripening. J. Fd. Sci. 40: 704-706.

Tolbert, B. M., Chen, A. W., Bell, E. M. and Baker, E. M. (1967): Metabolism of L-ascorbic-4-3H acid in man. Am. J. Clin. Nutr. 20: 250-252.

Vasudeva, N. and Gopal, N. H. (1972): Studies on ascorbic acid in coffee plants. Distribution in green fruits. J. Coffee Res. 2: 23-26.

Will, G. and Murdoch, W. R. (1960): Megaloblastic anaemia associated with adult scurvy. Post-Grad. Med. J. 36: 502-504.

Wilson, D. C. (1954): The nutrition of school girls in Northern Nigeria. Brit. J. Nutr. 8: 83-89.

Wilson, E. D., Fisher, K. H. and Fuqua, M. E. (1974): Principles of Nutrition. 2nd edition. John Wiley and Sons. Inc. New York and London.

Wilson, C. W. M. (1971): Vitamin C and the common cold. Brit. Med. J. 1: 669.

Worthington, E. B. (1936): On the food nutrition of African natives. Africa, London, 60: 150-165.

Yale, S. H., Jeffay, H., Mohammed, C. L. and Wach, E. C. (1959): Oral changes in normal and scorbutic guinea pigs injected with ascorbic acid 1-C14. J. Dent. Res. 38: 396-415.

Zadorozhnyi, T. M. (1974): Vitamin C content of chestnuts. Tovarovdiene, 7: 47-48. Abstracted from Food Science and Technology Abstracts, 6 (1975).

APPENDIX

Estimation of t-ratio

The estimated standard deviation of the difference between two treatment means is

$$Sd = \sqrt{S^2\left(\frac{1}{r_1} + \frac{1}{r_2}\right)}$$

where S^2 = error mean square.

r_1 and r_2 are the numbers of replicates for the two treatments.

Where $r_1 = r_2 = r$ the formula reduces

to $\sqrt{\frac{2S^2}{}}$

$$t = \frac{X_1 - X_2}{Sd}$$

The degrees of freedom for t-tests are $n_1 + n_2 - 2$.

QUESTIONNAIRE FOR FOOD CONSUMPTION SURVEY

Section A:- Personal data.

A1. Household no:

A2. House address:

A3. Ethnic group:

A4. Main language spoken:

A5. Years of residence in survey area:

A6. No of Household members:

A7. Years of age:

A8. Main occupation:
(Head of family)

Section B:- Food Supply

B1. Identify the sources of the following foods by placing an "X" in appropriate column.

	BUY	PRODUCE
Cereals (rice, ginea corn, millet, acha, maize)		
Fruits and vegetables (kuka, spinach, onions, tomatoes, carrots, garden egg etc.)		
Meat		
Milk		
Root and tubers (yams, potatoes, cassava)		
Legumes (peas, beans, soyabeans)		

B2. If you produce some of your foods do you think you had more foods than last planting season? Why?

Section C:- Foods Preparation & Distribution

C1. Who prepares the food daily?

Daughter (s) _____ Co-wives _____

Relative (s) _____ Neighbour (s) _____

Others _____

What measures are used?

C2. How many meals are cooked for everyone in the household to eat each day?

C3. Who is responsible for the overall distribution of food?

_____ Father

_____ Mother

_____ Other wives

_____ Elder daughters

_____ Others

C4. What measures are used in food distribution?

_____ Wooden scop

_____ Milk tin

_____ Mudu

_____ Others

D1. What kinds of food are eaten during:-

a. pre-planting season _____

b. Planting season _____

c. Harvest season _____

D2. What foods do you preserve?

_____ cereals (maize, acha, millet, guinea corn millet, rice)

_____ Roots and tubers (yam, potatoes, cassava)

_____ Fruits (melon, oranges, mangoes, carrots)

_____ Vegetables (kuka, bitterleaf, tomatoes, peppers)

D3. What methods of food preservation do you use?

_____ Drying

_____ Burying under the soil

_____ Canning

_____ Others

D4. How long do you store your preserved food?

_____ 1 week

_____ 1 month

_____ 2-4 months

6-12 months

E1. Which kind of soup do you like best with your basic food of cereals or starches.

_____1

_____2

_____3

E2. Which other vegetables do you like to eat?

1.

2.

3.

4.

5.

E3. How often do you eat vegetable?

(Interviewer should record the exact amount of vegetable soup consumed by individuals daily)

_____everyday

_____3 or 4 times a week

_____once a week

_____less than once a week

E4. What are the 3 fruits you like best?

1.

2.

3.

E.5 How often do you eat fruits?

_____everyday

_____3 or 4 times a week

_____once a week

_____less than once a week

E6. How do you eat fruit?

_____as part of a meal

_____as a snack eaten separately from meals.

E7. Do you like to use milk? If yes, which type do you like best?

_____fresh (cow, goat, sheep, camel)

_____powdered

_____concentrated (canned) 1

_____fulani sour milk 2

_____yoghurt 3

_____others

3. 24-hour CONSUMPTION RECALL

Kinds of foods	1st day B	L	D	S
Cereals, roots, tubers				
Vegetables and fruits (including ingredients of stews)				
Legumes (beans, soyabeans, peas)				
Nuts and seeds				
Meat or animal foods (including milk and cheese)				
Beverages				
Other foods				

FIG. 2 : MEAN ANNUAL RAINFALL OF NIGERIA (mm)

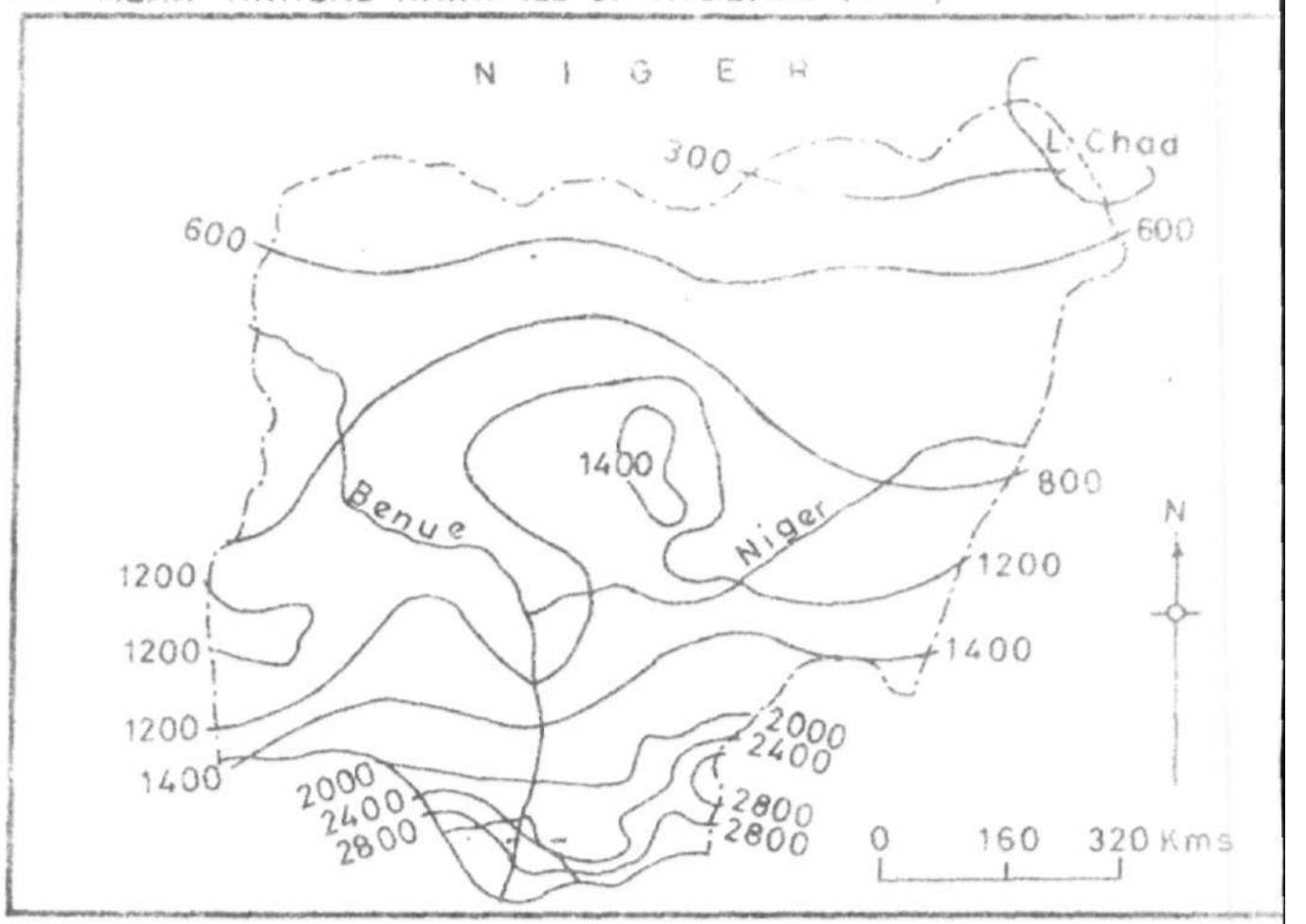


FIG.3 : LENGTH OF RAINY SEASON IN NORTHERN NIGERIA

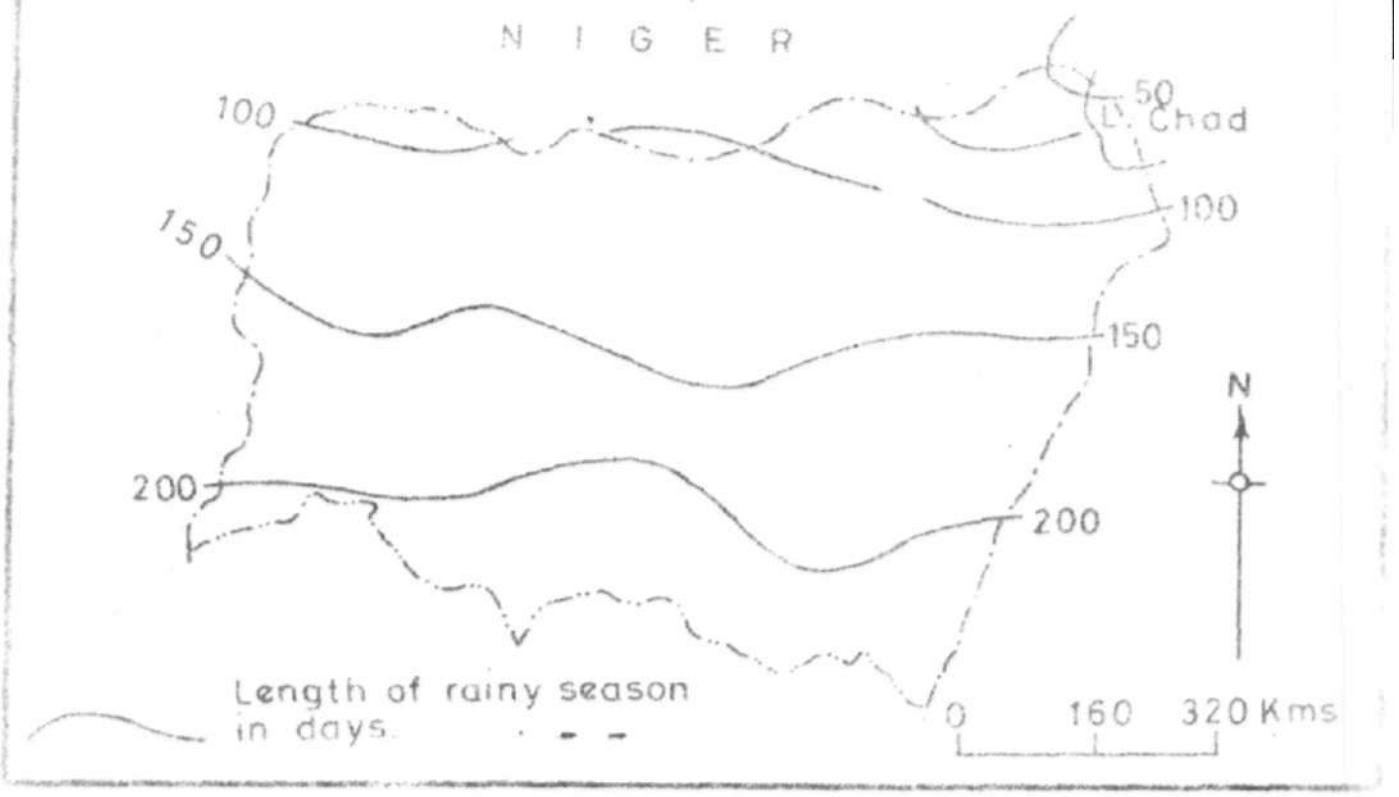
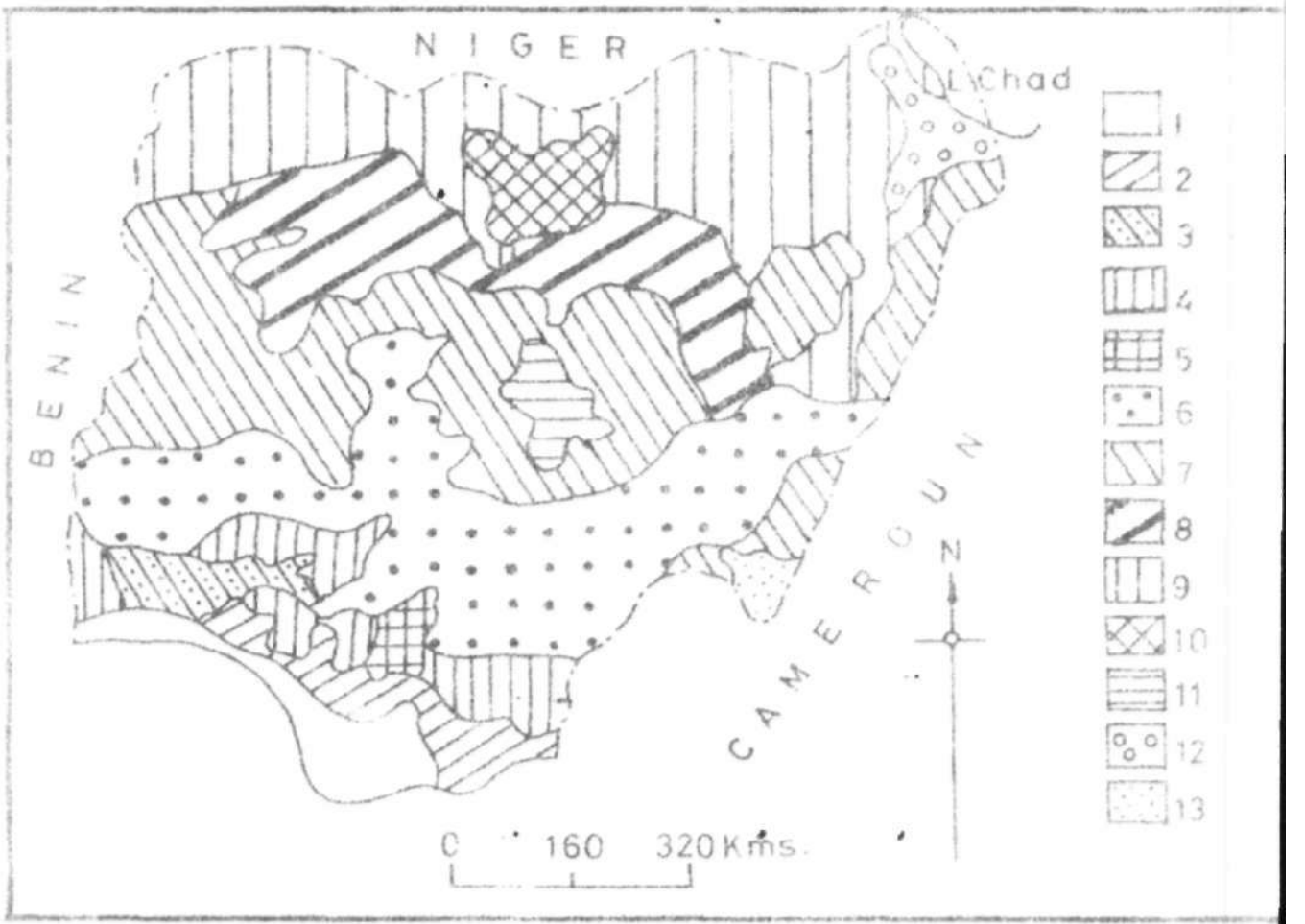


FIG.4 : TYPES OF CROP FARMING IN NIGERIA



11. Temperate food crops, vegetables as cash-crops, on Jos Plateau; finger millet, "hungry rice" (Digitaria exilis) and sorghum.

12. Dry-season sorghum and wheat zone, on Lake Chad black cotton soils.

13. High grassland zone; variety of crops, principally cocoyam, cassava, maize, sweet potatoes, bambarra groundnuts, African and European vegetables.

FIG 5: MAJOR FOODCROPS PECULIAR TO CERTAIN PARTS OF NIGERIA

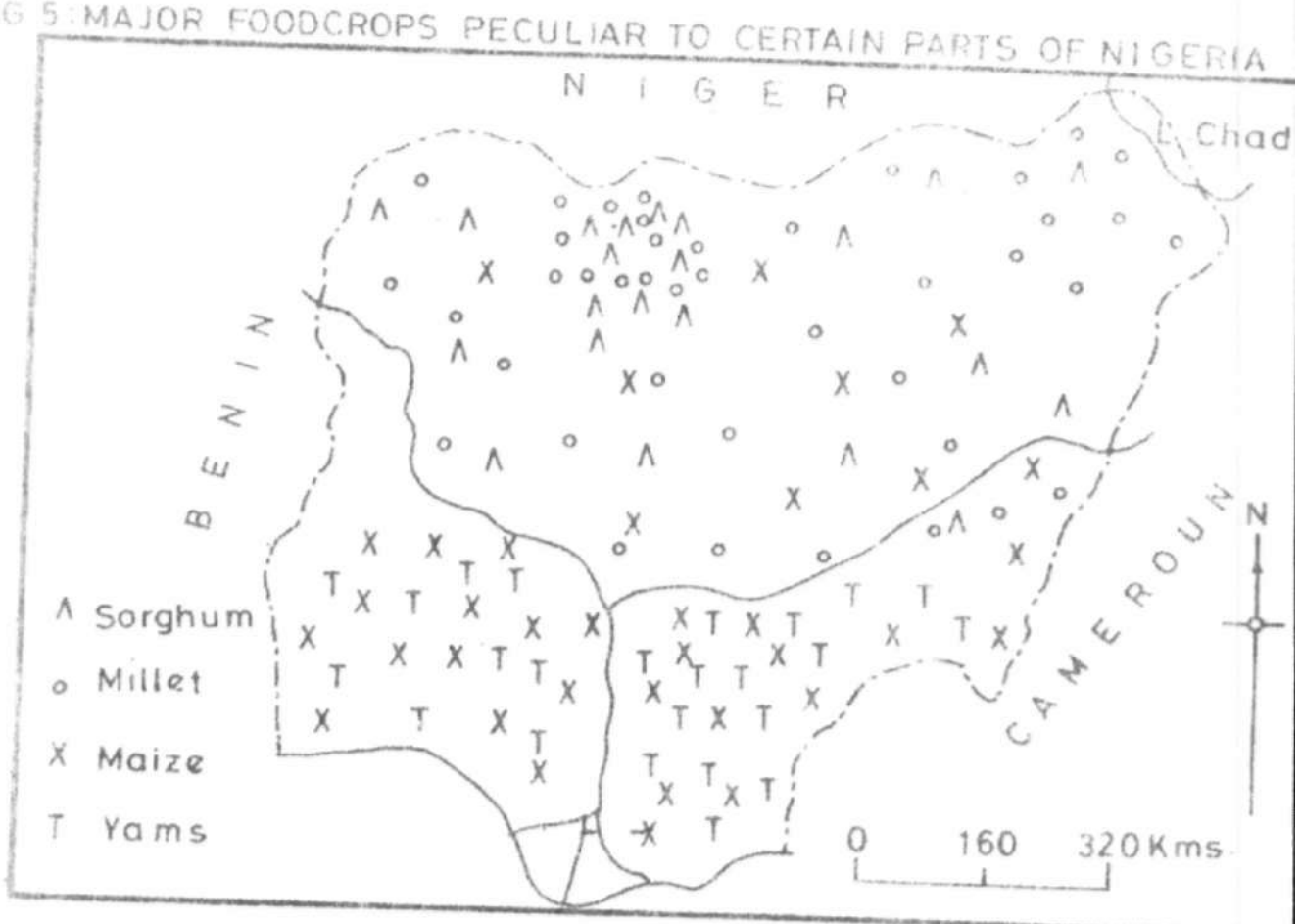
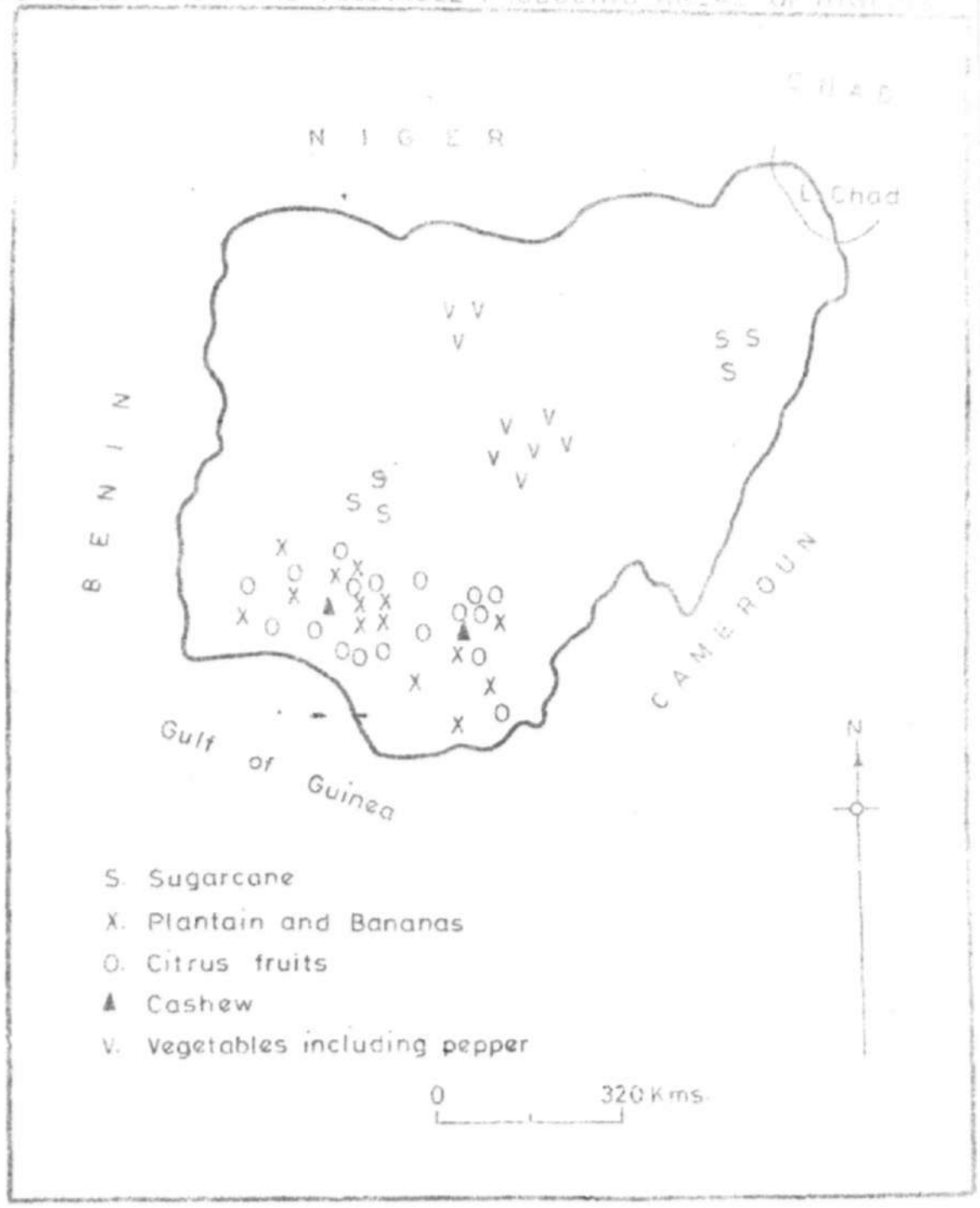


FIG 6 : MAJOR FRUIT AND VEGETABLE PRODUCING AREAS OF NIGERIA



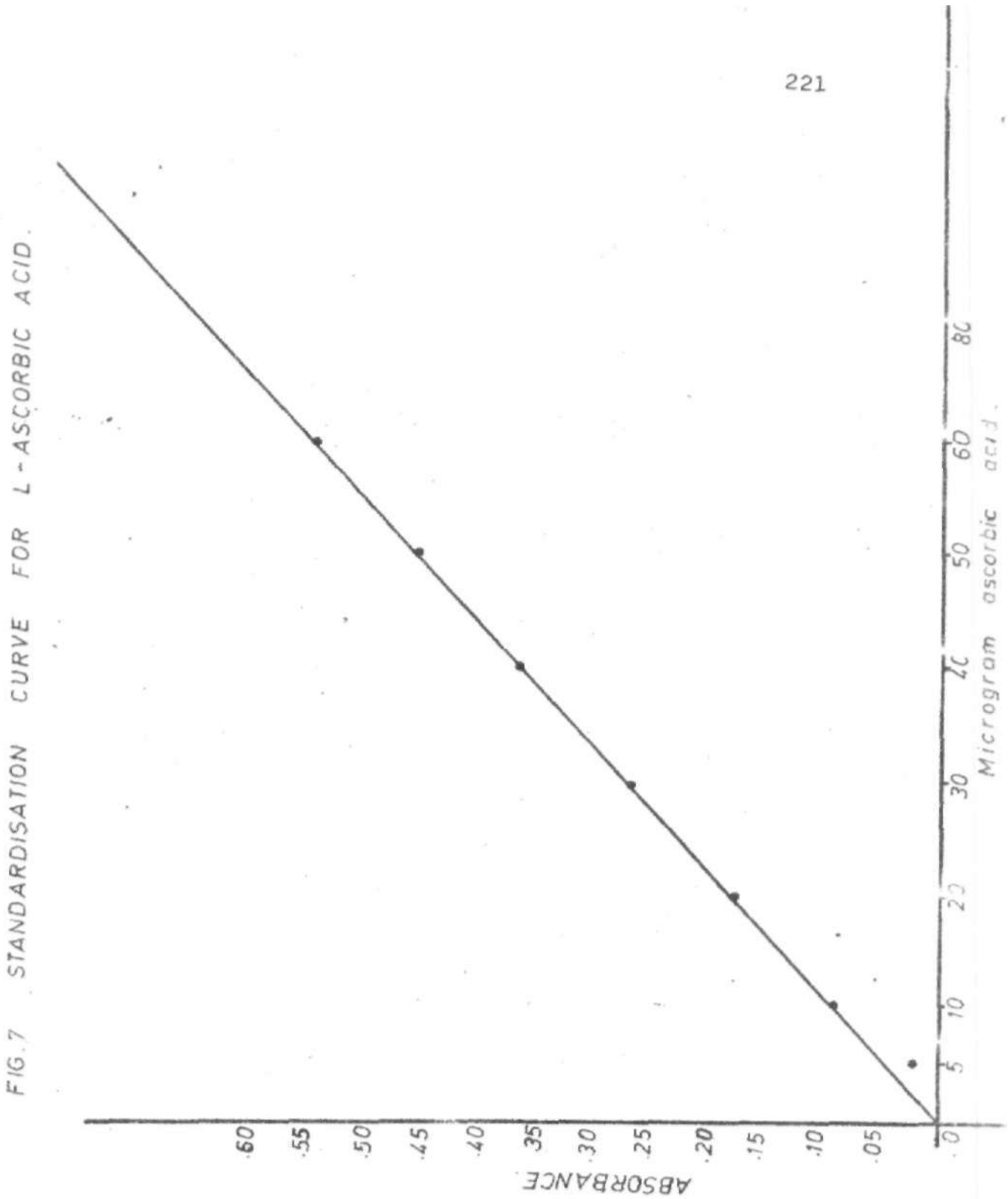


FIG. 7 STANDARDISATION CURVE FOR L-ASCORBIC ACID.

FIG.8 STANDARDISATION CURVE FOR PLASMA ASCORBIC ACID.

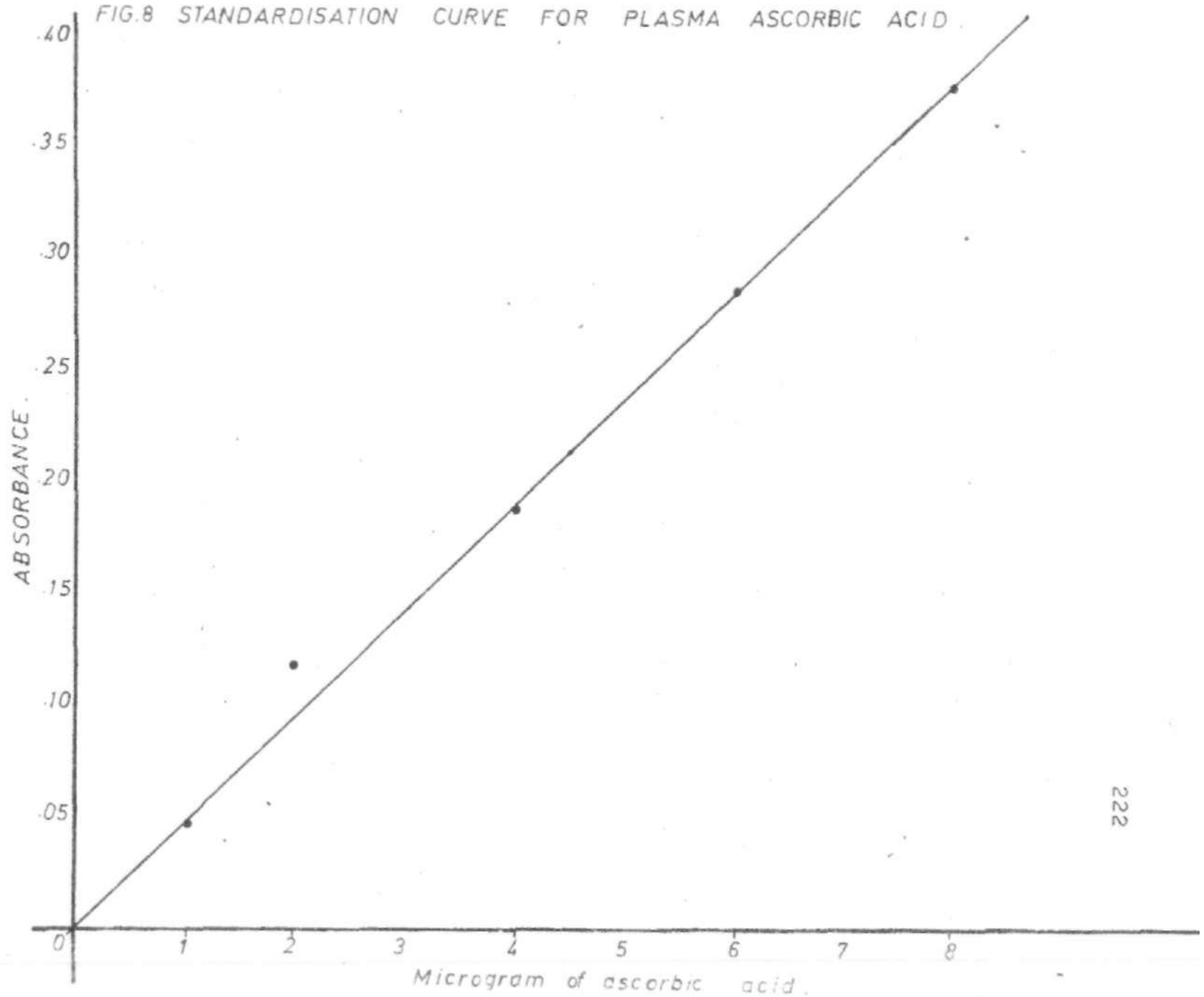


FIG.9 STANDARDISATION CURVE FOR CREATININE.

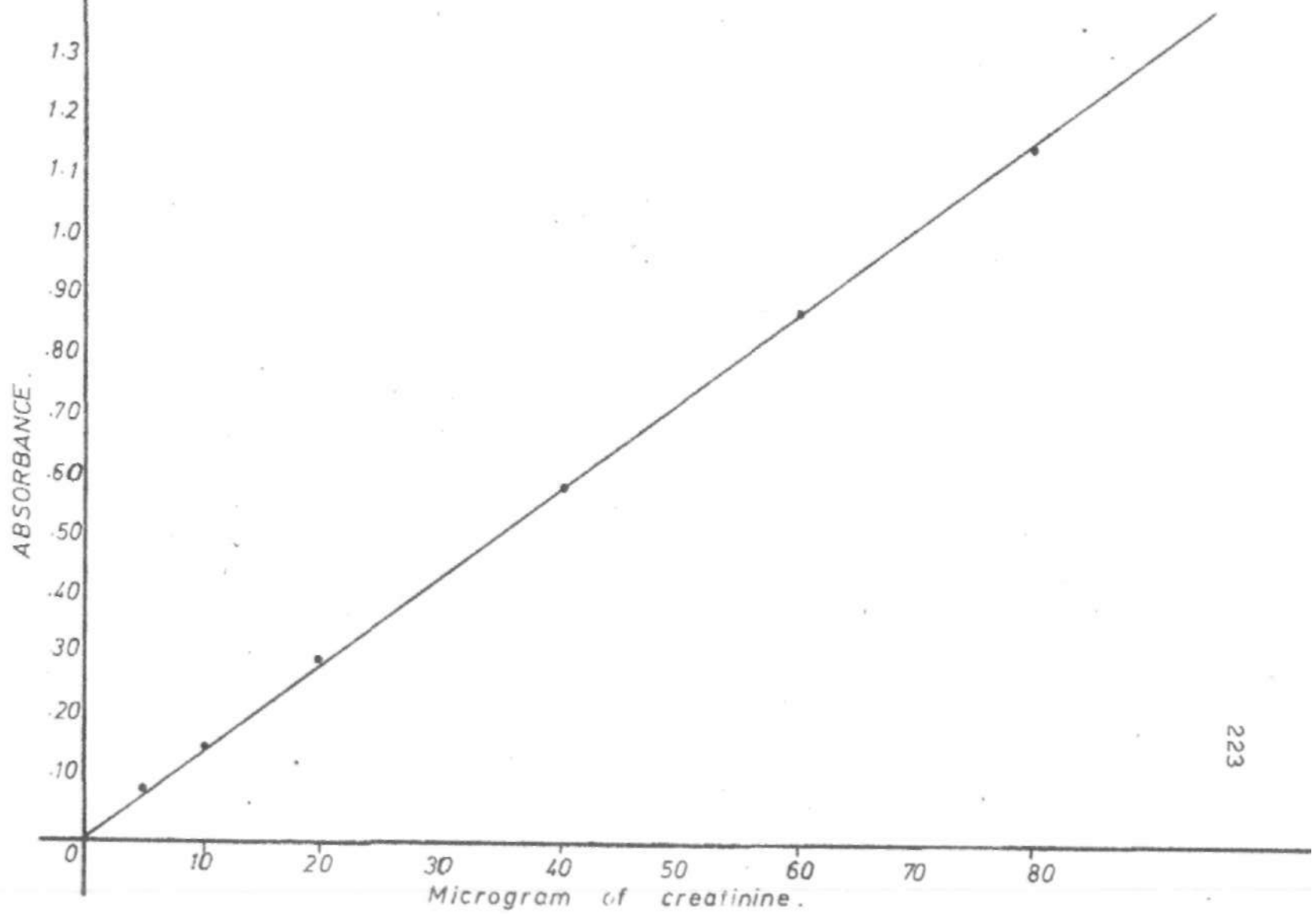


FIG.10 CHANGES IN PLASMA AND URINARY LEVE OF ASCORBIC ACID OF HUMAN VOLUNTEERS DUE TO FEEDING OF KUKA SOUP AS COMPARED TO SUPPLEMENTAL ASCORBIC . ACID TABLET.

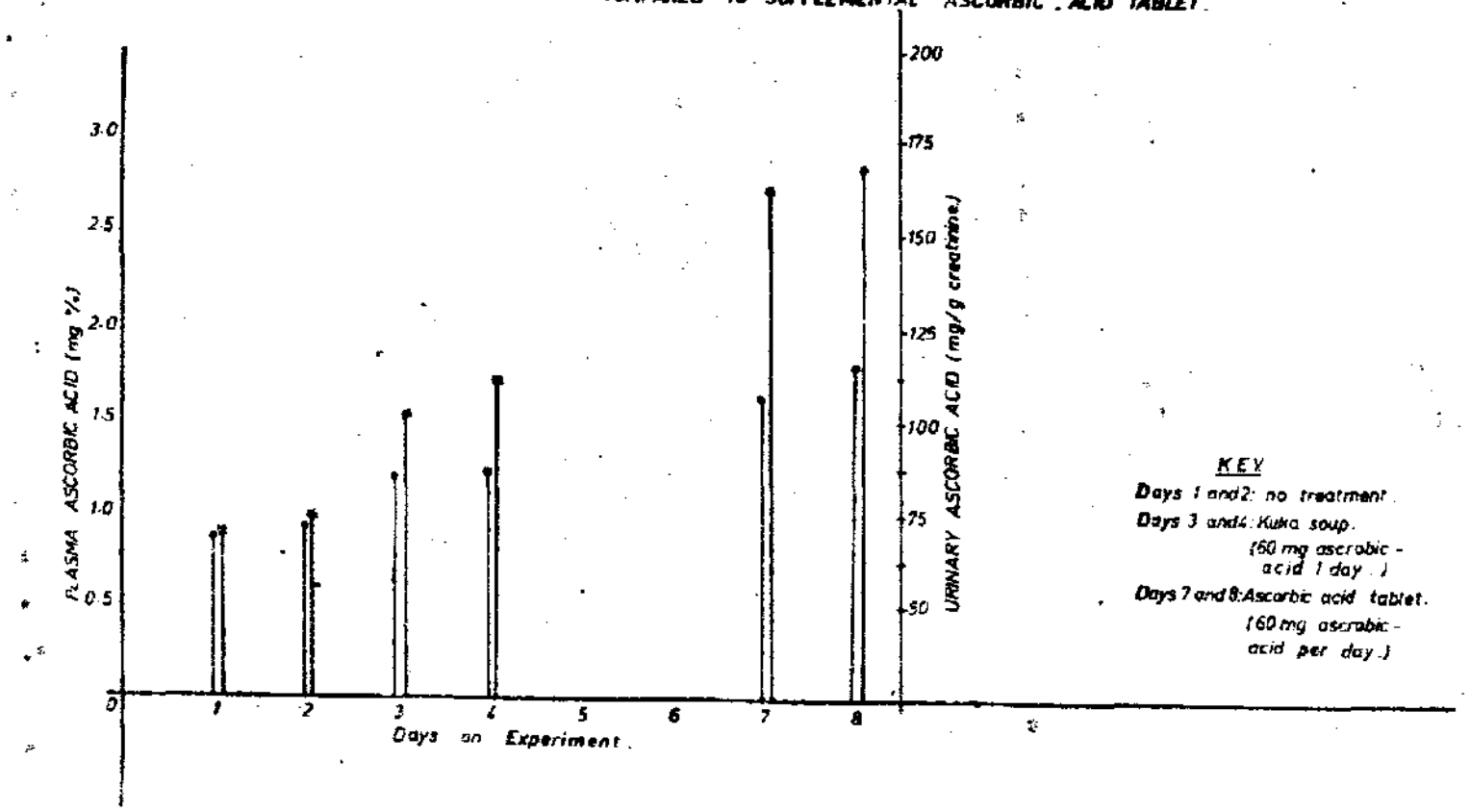


TABLE 1: TOTAL ASCORBIC ACID INTAKE OF RURAL CHILDREN AGED TWO TO FOUR YEARS DURING RAINY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Tea	2,009	•	Millet Pap	264	•	Maize	500	•
Bread	261	0	Sugar	242	0	Guinea corn Pap	1,624	0
Guinea corn Pap	1,538	0	Tea	1,914	0	Bean cake	240	••
Bean cake	624	0	Bread	287	0	Waina	317	••
Sugar	219	0	Sweet potatoes	540	32.78	Rice and Beans	438	•
Milk	87	1.74	Yam pottage	802	17.16	Fura	445	0
Tuwon shinkafa	689	•	Milk	100	2.0	Nono	2,113	76.28
Kalkashi soup	94•	113.18	Sorrell/Melon soup	54	3.26	Tuwon dawa	2,007	0
Okro soup	1,581	205.74	Pumpkin/Okro	324	51.84	Kuka soup	5,043	829.15
Spinach/Sorrell soup	62	•	Tuwon dawa	1,991	0	Groundnuts	184	•
Tuwon dawa	3,484	•	Fura	332	0	Kalkashi soup	803	96.76
Kuka soup	4,483	738.97	Nono	3,128	112.92	Sugar	257	•
Boiled maize	484	•	Okro soup	602	109.56	Meat	1,282	0
Roasted maize	275	•	Tuwon shinkafa	818	0	Tea	1,845	•
Garden Egg	84	17.55	Fish	92	0	Bread	392	0
Meat	262	0	Meat	207	•	Milk	124	2.48
Groundnut cake		0	Roasted maize	625	0	Okro soup	223	42.82
			Kuka soup	4,273	718.9	Meat stew	150	2.12
TOTAL	1,107.7		TOTAL	1,041.96		TOTAL	1,140.95	
MEAN	58.3		MEAN	54.84		MEAN	60.05	

TABLE 1: (Cont'd)

FOOD	DAY 4 Wt. (gm)	As. Acid (mg)	FOOD	DAY 5 Wt. (gm)	As. Acid (mg)
Guinea corn pap	1,460	0	Tea	752	0
Bean cake	341	0	Bread	260	0
Tea	1,725	0	Sugar	317	0
Bread	151	0	Milk	89	1.78
Milk	87	1.74	Nono	1,874	67.65
Sugar	262	0	Fura	498	0
Yam pottage	207	4.43	Beans	68	0
Sorrell leaves			Jollof rice with vegetables	415	1.45
Sweet potatoes	605	36.72	Tuwon dawa	1,983	0
Tuwon dawa	1,841	0	Cocoyam	43	0.51
Tuwon masara	434	0	Guinea corn pattage	252	1.31
Kuka soup	4,327	703.86	Sweet potatoes	784	47.59
Melon/bitterleaf soup	40	0.48	Kuka soup	4,440	739.67
Meat	315	0	Spinach/pumpkin soup	67	9.63
Guava	60	79.8	Boiled maize	285	0
Okro soup	368	70.66			
TOTAL	981.92		TOTAL	923.78	
MEAN	51.68		MEAN	48.62	

TABLE 2: TOTAL ASCORBIC ACID INTAKE OF RURAL CHILDREN AGED TWO TO FOUR YEARS DURING DRY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Tea	1,257	0	Maize pap	327	0	Guinea corn pap	1,309	0
Bread	307	0	Guinea corn pap	1,344	0	Bean cake	532	0
Guinea corn pap	1,200	0	Bean cake	723	0	Tea	1,784	0
Maize	450	0	Bread	189	0	Bread	200	0
Bean cake	798	0	Tea	2,064	0	Maize pap	502	0
Dan-wake	136	0	None	2,837	74.05	Rice	687	0
Tuwon dawa	850	0	Fura	492	0	Beans	173	0
Tuwon masara	154	0	Yam pottage	379	8.11	Tuwon dawa	872	0
Milk	86	1.72	Acha pottage	125	1.46	Yakuwa soup	69	48.7
Okro soup	608	26.27	Tuwon dawa	1,006	0	Kuka soup	4,724	427.84
Kuka soup	3,743	581.02	Kalkashi soup	964	29.31	Meat	301	0
Yams	184	7.47	Pumpkin soup	87	0.9	Okro soup	543	18.3
Fura	507	0	Tuwon masara	250	0	Guinea corn pottage	150	1.53
None	1,980	71.48	Tuwon shinkafa	208	0	Groundnut cake		0
Sweet potatoes	234	23.70	Sugar cane	534	21.95	Nono	2,428	87.65
Groundnut soup	56	0	Okro soup	803	35.09	Fura	502	0
Sugar cane	487	29.76	Kuka soup	3,821	467.65	Milk	70	1.4
Roasted groundnut	165	0	Groundnuts	150	0	Sugar	725	0
Spinarch/sorrell soup	44	3.99	Meat	181	0			
Groundnut cake		0	Fish	68	0			
Rice	351	0	Milk	92	1.84			
Meat	284	0	Sugar	300	0			
Spinach/mellon soup	51	3.27						
Sugar	279	0						
Total	748.03		Total	645.05		Total	380.26	
Mean	39.37			33.95			30.54	

Grand average 35.35

TABLE 2 (Cont'd)

DAY 4 FOOD	Wt. (gm)	As. Acid (mg)	DAY 5 FOOD	Wt. (gm)	As. Acid (mg)
Waina	202	0	Maize	214	0
Bean cake	600	0	Bean cake	407	0
Guinea corn pap	1,271	[illegible]	Guinea corn pap	1,508	0
Tea	1,483	0	Milk	100	2.0
Bread	267	0	Sugar	247	0
Milk	84	1.68	None	1,981	51.7
Sugar	322	0	Fura	389	0
Pidgeon peas	87	[illegible]	Tuwon shinkafa	124	[illegible]
Pounded yam	104	0	Okro soup	621	27.14
Spinach/melon soup	102	6.55	Tuwon dawa	1,210	0
Rice with v'tables	341	3.75	Kuka soup	2,935	495.93
Tuwon dawa	1,004	[illegible]			0
Kuka soup	4,307	616.89	Sweet potatoes	328	19.91
Okro soup	633	27.66	Meat stew	133	1.88
Fura	400	0	Yam pottage	241	5.16
Nono	891	32.17	Tea	1,417	0
Groundnut cake		0	Bread	342	0
Meat	201	0	Sugar cane	202	12.34
Dried fish	57	0	Kunun Zaki	225	28.22
Garden egg	243	50.76			
Total	740.05		Total	644.67	
Mean	38.95		Mean	33.93	

TABLE 3: TOTAL ASCORBIC ACID INTAKE OF SUB-URBAN CHILDREN AGED TWO-FOUR YEARS DURING RAINY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Tea	1,714	0	Maize pap	402	0	Bread	502	0
Sugar	324	0	Guinea corn pap	673	0	Guinea corn pap	1,802	0
Milk	94	1.88	Bean cake	418	0	Bean cake	683	0
Guinea corn pap	1,625	0	Fura	627	0	Gari	867	0
Bean cake	798	0	Nono	3,004	108.44	Semovita	584	0
Rice	672	0	Boiled groundnuts	421	0	Kalkashi soup	934	11.55
Meat stew	73	1.03	Tuwon shinkafa	483	0	Spinach/beniseed Soup	76	1.55
Spinach/melon soup	95	5.15	Bean soup	150	0	Biscuits	81	0
Tuwon dawa	1,930	0	Okro soup	558	107.14	Tea	1,941	0
Kuka soup	1,649	292.53	Tuwon dawa	971	0	Guava	67	89.13
Tuwon acha	752	0	Kuka soup	2,214	447.79	Sugar	299	0
Spinach/sorrell/ Melon soup	101	9.15	Fish	90	0	Milk	109	2.18
			Popcorn	40	0	Yam pottage	634	13.57
Boiled groundnuts	322	0	Sweets	30	0	Tuwon acha	708	0
Boiled maize	279	0	Rice	250	0	Tuwon dawa	936	0
Meat	301	0	Spinach/Melon soup	143	6.32	Kuka soup	2,271	450.54
Okro soup	843	161.86				Sweets	45	0
Fura	412	0	Meat stew	69	0.97	Boiled maize	337	0
Nono	2,634	95.09	Meat	228	0	Eggs	174	0
			Semovita	289	0	Ayoyo soup	843	
			Ayoyo soup	569	33.29	Yam flour	250	0
Total	569.38		Total	705.60		Total	669.90	
Mean	40.67		Mean	50.4		Mean	47.85	
						Grand average	45.93	

TABLE 3; (Cont'd)

FOOD	DAY 4 Wt. (gm)	As. Acid (mg)	FOOD	DAY 5 Wt. (gm)	As. Acid (mg)
Fresh potatoes	1,288	0	Tea	1,347	0
Bread, Meat & stew	74	1.04	Bread	283	0
Bread	354	0	Sugar	324	0
Tea	2,089	0	Milk	108	2.16
Sweet potatoes	581	35.27	Maize pap	831	0
Guinea corn pap	432	0	Bean cake	402	0
Alele	206	0	Yam	803	33.7
Jollof rice	250	1.75	Meat stew	142	
Tuwon dawa	1,004	0	Biscuits	64	0
Kuka soup	2,803	382.97	Garden egg	296	61.83
Yam	600	24.36	Groundnut cake		0
Spinach/melon soup	125	6.78	Roasted maize	280	0
Orange	61	33.74	Boiled maize	331	0
Boiled cassava	172	21.17	Vegetable salad	105	1.71
Zogala					
Roasted maize	341	0	Rice	534	0
Boiled maize	207	0	Spinach/melon soup	135	8.67
Tuwon shinkafa	730	0	Tuwon dawa	833	0
Okro soup	981	188.35	Kalkashi soup	1,516	182.68
Fura	285	0	Tuwon acha	270	0
Nono	1,250	45.13	Spinach/bitterleaf soup	84	6.75
Sugar	413	0	Acha pottage	138	1.61
Eggs	120	0	Yam pottage	482	10.31
			Kuka soup	1,326	218.57
Total	740.74		Total	529.20	
Mean	52.91		Mean	37.8	

TABLE 4: TOTAL ASCORBIC ACID INTAKE OF [illegible]-URBAN CHILDREN AGED TWO TO FOUR YEARS DURING DRY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Tea	2,2[illegible]	(	Guinea corn pap	1,230	(	Bread	428	(
Bread	194	(	Alele	184	0	Tea	2,02[illegible]	(
Egg	128	(	Bean cake	594	(	Salmon fish	54	(
Yam	197	8.0	Tea	1,814	0	Tuwon dawa	327	(
Meat stew	164	2.31	Bread	301	0	Kalkashi soup	814	900.99
Sugar cane	7[illegible]2	42.89	Tuwon masara	160	(	Okro soup	873	187.42
Beans	15[illegible]	?	Kuka soup	1,057	29.5	Ayoyo soup	376	38.2[illegible]
Rice	923	0	Ayoyo soup	341	34.68	Spinach/sorrell soup	44	3.99
Tuwon dawa	581	0	Sugar	292	0	Bean cake	300	0
Yam pottage	244	5.22	Milk	74	1.48	Maize pap	350	0
Dates	61	0	Meat	3,024	(	Meat	274	(
Okro soup	833	36.4	Fish	89	0	Semovita	300	(
Kuka soup	940	245.69	Pounded yam	136	0	Yam flour	254	0
Sweet potatoes	304	18.45	Rice	427	0	Tuwon shinkafa	87	(
Biscuit	107	(	Yam flour	92	0	Sugar	421	(
Spinach/melon soup	91		Gari	84	0	Milk	103	2.0[illegible]
Meat	343	0	Acha pottage	124	2.65	Fura	5[illegible]0	0
Sugar	328	0	Groundnuts	101	0	Nono		67.15
Milk	89	1.78	Eggs	180	0	Kunun Zaki	150	18.81
Oats porridge	216	0	Okro soup	305	58.56	Yam	176	7.15
Garden egg	200	41.78	Sugar cane	498	30.43	Sugar cane	243	14.85
						Pineapple juice	150	33.[illegible]
Total	402.50		Total	423.92		Total	470.12	
Mean	28.75		Mean	30.28		Mean	33.58	

Grand Mean 31.23

TABLE 4: (Cont'd

DAY 4 FOOD	Wt. (gm)	As. Acid (mg)	DAY 5 FOOD	Wt. (gm)	As. Acid (mg)
Tea	1,342	0	Waina	98	0
Sweet potatoes	402	24.04	Guinea corn pap	463	0
Bread	317	0	Bean cake	201	0
Guinea corn pap	892	0	Tea	2,203	0
Bean cake	284	0	Bread	289	0
Alele	124	0	Sugar	229	0
Pop corn	50	0	Milk	147	2.94
Groundnut cake		0	Plantains	176	5.3
Spinach/melon soup	89	5.71	Meat stew	80	1.13
Tuwon shinkafa	346	0	Sugar cane	169	10.33
Orange	134	74.12	Tuwon dawa	344	0
Meat	210	0	Spinach/bitterleaf/ melon soup	128	10.29
Fish	62	0	Banana	90	24.62
Tuwon dawa	437	0	Semovita	270	0
Kuka soup	1,840	306.36	Okro soup	256	49.14
Fura	416	0	Tuwon masara	174	0
Nono	927	33.46	Spinach/pumpkin soup	102	14.28
Sugar cane	194	11.85	Chicken	72	0
Meat stew	73	1.03	Beans	68	0
Acha pottage	121	1.42	Rice	233	0
Yam	200	8.12	Spinach/Beniseed soup	116	5.8
Corn flakes	55	0	Fish	104	0
Milk	300	6.0	Kuka soup	1,853	290.18
Sugar	314	0			
Total	472.50		Total	417.20	
Mean	33.75		Mean	29.8	

TABLE 5: TOTAL ASCORBIC ACID INTAKE OF URBAN CHILDREN AGED TWO TO FOUR YEARS DURING RAINY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Millet pap	489	0	Waina	251	0	Sweet potatoes	150	9.11
Guinea corn pap	591	0	Tea	1,543	•	Meat stew	75	1.06
Sugar	234	0	Bread	358	0	Tea	1,431	0
Bean cake	622	0	Maize pap	498	0	Bread	243	•
Dan-wake	100	0	Alele	168	0	Waina	187	•
Tuwon dawa	568	0	Milk	123	2.46	Guinea corn pap	634	0
Kuka soup	701	143.14	Fura	548	0	Bean cake	400	•
Semovita	436	•	Nono	2,232	80.58	Milk	178	3.56
Okro soup	872	16.42	Plantain	257	5.17	Sugar	450	0
Meat	349	0	Rice	687	0	Yam pottage	639	13.67
Beans	214	•	Fried yam	432	13.22	Tuwon masara	543	0
Garden egg	226	47.21	Gari	381	0	Melon/bitterleaf soup	103	1.06
Fura	485	•	Okro soup	919	176.45	Kalkashi soup	984	118.57
Nono	1,723	62.2	Tuwon dawa	762	0	Yam flour	250	•
Roasted maize	384	0	Tuwon shinkafa	621	0	Ayoyo soup	507	51.56
Tiger nuts	84	•	Kuka soup	543	111.09	Tuwon dawa	821	•
Pineapple drink	248	34.56	Kalkashi soup	807	97.24	Kuka soup	949	193.79
Tea	1,87•	•	Fish	250	0	Orange	45	24.89
Milk	133	2.66	Meat stew	201	2.83	Boiled maize	250	•
			Guava	47	43.85	Salmon	180	•
			Egg	160	•	Meat	424	•
			Sugar	387	0			
Total	477.19		Total	532.89		Total	417.27	
Mean	47.71		Mean	53.28		Mean	41.72	
			Grand Average	45.25				

TABLE 5: (Cont'd)

DAY 4 FOOD	Wt. (gm)	As. Acid (mg)	DAY 5 FOOD	Wt. (gm)	As. Acid (mg)
Sweet potatoes	75	4.55	Guinea corn pap	943	0
Eggs	192	0	Alele	203	0
Tea	1,843	0	Bean cake	487	0
Pancake	79	0	Tea	1,230	0
Guinea corn pap	640	0	Fura	450	0
Bean cake	552	0	Nono	2,008	72.49
Sugar	470	0	Meat stew	129	1.82
Milk	89	1.78	Rice	165	0
Beans	165	0	Gari	151	0
Macarroni	83	0	Spinach/beniseed soup	88	0.96
Tuwon dawa	741	0	Sweet	48	0
Kuka soup	938	191.54	Boiled maize	289	0
Tuwon shinkafa	623	0	Tiger nuts	37	0
Okro soup	1,029	197.57	Beans	59	16.14
Buiscuit	75	0	Tuwon dawa	589	0
Groundnut cake		0	Kuka soup	901	183.94
Fura	525	0	Sugar	297	0
Nono	2,400	86.64	Plantain	102	2.05
Meat	402	0	Tuwon shinkafa	530	0
Ribena fruit drink	150	6.0	Kalkashi soup	2,979	117.97
Meat	298	0	Meat	298	0
			Garden egg	200	41.78
Total	488.08		Total	347.21	
Mean	48.81		Mean	34.72	

TABLE 6: TOTAL ASCORBIC ACID INTAKE OF [illegible]ILDREN AGED TWO TO FOUR YEARS DURING DRY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Tea	1,450	0	Yam	681	27.65	Fried yam	450	9.27
Waina	250	0	Meat stew	207	2.92	Fried sweet potatoes	384	11.79
Bread	538	0	Bread	250	0	Eggs	159	0
Guinea corn pap	894	0	Tea	1,305	0	Meat stew	134	1.89
Bean cake	327	0	Eggs	164	0	Tea	1,540	00
Sugar	311	0	Pounded yam	102	0	Maize pap	580	0
Milk	124	2.48	Okro soup	370	16.17	Sugar	338	0
Groundnuts	423	0	Sugar	412	0	Milk	119	2.38
Yam pottage	536	11.47	Milk	97	1.94	Gari	505	0
Semovita	508	0	Meat	2,294	0	Ayoyo soup	802	81.56
Okro soup	230	44.1	Tuwon dawa	741	-	Semovita	325	0
Tuwon dawa	976	0	Kuka soup	584	119.26	Kalkashi soup	743	78.02
Kuka soup	873	178.27	Tuwon masara	687	0	Rice	624	0
Groundnut cake		0	Melon/bitterleaf soup	114	0.97	Tuwon dawa	1,200	0
Rice	459	0	Kalkashi soup	570	68.69	Kuka soup	812	165.81
Tiger nuts	210	0	Nono	2,874	103.75	Meat	214	0
Garden eggs	451	94.21	Fura	623	0	Groundnut cake		0
Meat stew	80	1.13	Groundnuts	340	0	Sweets	53	0
Tuwon shinkafa	687	0	Orange drink	150	82.97	Margarine	43	0
Spinach/sorrell soup	42	3.81	Dan-wake	89	0	Nono	1,224	44.19
Meat	481	0				Fura	425	0
Total	335.47		Total	424.3		Total	394.89	
Mean	33.55		Mean	42.43		Mean	39.49	
			Grand Average	37.49				

TABLE 6: (Cont'd)

FOOD	DAY 4 Wt. (gm)	As. Acid (mg)	FOOD	DAY 5 Wt. (gm)	As. Acid (mg)
Millet	500	0	Pancake	130	0
Waina	123	0	Guinea corn pap	492	0
Alele	186	0	Bean cake	302	0
Bean cake	274	0	Tea	1,458	0
Yam pottage	636	13.61	Milk	121	2.42
Tuwon masara	824	0	Sugar	343	0
Okro soup	501	96.19	Tuwon dawa	839	0
Rice	535	0	Kuka soup	801	163.56
Meat stew	130	1.83	Meat	413	0
Yam flour	252	0	Semovita	388	0
Kalkashi soup	967	116.52	Okro soup	960	184.32
Garden egg	138	7.94	Gari	425	0
Tuwon dawa	789	0	Spinach/melon soup	143	7.75
Kuka soup	234	47.74	Sugar cane	704	43.01
Tiger nuts	60	0	Plantain	184	3.66
Sugar	317	0	Meat stew	136	1.92
Maize pap	403	0	Biscuits	68	0
Sugar cane	621	37.94	Fura	582	0
Pineapple drink	284	62.48	Nono	802	28.95
Meat	390	0			
Fish	302	0			
Total	384.25		Total	435.59	
Mean	38.43		Mean	43.56	

TABLE 7: TOTAL ASCORBIC ACID INTAKE OF RURAL CHILDREN AGED FIVE-SEVEN YEARS DURING RAINY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Maize pap	463	0	Guinea corn pap	1,090	0	Guinea corn pap	2,210	0
Guinea corn pap	2,000	0	Bean cake	231	0	Tea	1,914	0
Bean cake	384	0	Tea	2,0812	0	Bread	618	0
Sugar	91	0	Bread	720	0	Sugar	238	0
Yam pottage	1,050	22.47	Sugar	120	0	Milk	208	4.16
Tuwon dawa	4,750	0	Milk	250	5.0	Bean cake	284	0
Tuwon masara	963	0	Tuwon dawa	2,070	0	Waina	392	0
Kuka soup	5,875	841.18	Okro/pumpkin soup	238	24.70	Groundnuts	750	0
Spinach/melon soup	1,720	146.22	Kuka soup	4,802	624.56	Tuwon dawa	2,133	0
						Kuka soup	5,921	1216.90
Groundnut cake		0	Nono	6,435	276.95	Tuwon masara	632	0
Meat	374	0	Fura	2,307	0	Rice	750	0
Garden egg	122	25.48	Yam	830	33.70	Beans	627	0
Okro soup	2,400	278.8	Meat stew	209	2.94	Meat stew	1,002	14.13
Tuwon shinkafa	6,032	0	Boiled maize	334	0	Okro soup	4,326	365.85
Dan-wake	298	0	Cocoyam	782	105.51	Melon/bitter-leaf soup	150	12.30
Boiled maize	152	0	Tuwon shinkafa	1,571	0	Sweet potatoes	4,300	118.25
Kalkashi soup	3,300	430.78	Meat	443	0	Nono	1,943	50.14
			Spinach/melon soup	640	4.10	Fura	964	0
						Meat	1,534	0
						Roasted maize	319	0
Total	1,671.48		Total	1,074.24		Total	1,781.45	
Mean	92.86		Mean	59.68		Mean	98.97	

Grand Average 79.11

TABLE 7: (Cont'd)

DAY 4 FOOD	Wt. (gm)	As. Acid (mg)	DAY 5 FOOD	Wt. (gm)	As. Acid (mg)
Guinea corn pap	1,875	0	Millet pap	489	0
Tea	2,433	0	Bean cake	292	0
Bread	412	0	Tea	2,324	0
Bean cake	301	0	Bread	294	0
Sugar	204	0	Sugar	183	0
Milk	102	2.04	Milk	162	3.24
Jollof rice with v' vegetables	154	1.69	Waina	483	0
Guinea corn pottage	182	1.85	Rice and beans	330	0
			Jollof rice with vegetables	481	5.77
Boiled maize	105	0	None	1,302	46.09
Tuwon dawa	1,428	0	Fura	687	0
Meat stew	430	7.83	Tuwon shinkafa	891	0
Yams	756	30.69	Kuka soup	6,563	939.71
Kuka soup	5,403	862.87	Okro soup	1,728	301.42
Tuwon masara	2,400	0	Tuwon dawa	1,912	0
Oranges	56	30.97	Groundnut cake		0
Tiger nuts	94	0	Meat	303	0
Garden egg	389	88.59	Fish	87	0
Spinach/pumpkin soup	138	19.84	Spinach/sorrell pumpkin soup	207	16.6
Okro soup	1,765	162.18	Garden egg	102	21.26
Fura	504	0	Guinea corn pap	824	0
None	1,124	85.52	Boiled maize	287	0
Meat	576	0			
Total	1,278.18		Total	1,314.18	
Mean	71.01		Mean	73.01	

TABLE 8: TOTAL ASCORBIC ACID INTAKE OF RURAL CHILDREN AGED FIVE-SEVEN DURING DRY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Guinea corn	1,820	0	Tea	2,724	0	Maize pap	381	0
Bean cake	241	0	Guinea corn pap	872	0	Millet pap	433	0
Tea	1,912	0	Bean cake	193	0	Bean cake	271	0
Bread	607	0	Bread	304	0	Waina	64	0
Yam	489	19.88	Milk	151	3.62	Sugar	150	0
Meat stew	133	1.87	Sugar	208	0	Tea	1,997	0
Yam pottage	620	13.27	Sweet potatoes	336	20.39	Bread	581	0
Tuwon dawa	4,573	0	Cassava and rama	256	16.05	Milk	97	1.94
Kalkashi soup	1,050	52.5	Sugar cane	301	18.39	Rice & Bean	386	0
Kuka soup	4,920	527.76	Tuwon daga	1,517	0	Tuwon dawa	4,327	0
Tuwon masara	823	0	Tuwon shinkafa	1,018	0	Tuwon masara	3,905	0
Groundnut soup	250	0	Okro soup	567	24.77	Okro soup	874	38.19
Sugar cane	787	48.0	Kuka soup	3,589	120.27	Spinach/melon soup	146	19.37
Meat	314	0	Nono	7,007	272.65	Kuka soup	3,568	455.12
Fish	68	0	Fura	639	0	Sugar cane	501	30.61
Milk	152	3.04	Groundnut cake		0	Garden egg	150	10.44
Sugar	200	0	Beans	105	0	Dried fish	67	0
Fura	578	0	Meat stew	98	1.38	Kunun Zaki	194	24.32
Nono	1,002	26.17	Meat	407	0	Yam pottage	583	12.47
Kunun Zaki	227	28.46	Pumpkin/spinach			Meat	301	0
Dan-wake	82	0	scup	89	9.24	Sweet potatoes	180	10.92
			Garden egg	43	8.98	Meat stew	133	1.87
Total	744.48		Total	664.02		Total	664.38	
Mean	41.36		Mean	36.89		Mean	36.91	

Grand average = 40.96

TABLE 8: (Cont'd)

DAY 4 FOOD	Wt. (gm)	As. Acid (mg)	DAY 5 FOOD	Wt. (gm)	As. Acid (mg)
Guinea corn pap	1,701	0	Tea	1,988	0
Bean cake	98	0	Guinea corn pap	348	0
Waina	74	0	Bean cake	79	0
Tea	2,233	0	Milk	176	3.52
Bread	407	0	Sugar	193	0
Milk	69	1.38	Bread	569	0
Sugar	159	0	Guinea corn pottage	257	2.62
Tuwon shinkafa	3,234	0	Tuwon dawa	1,892	0
Okro soup	1,540	23.59	Okro soup	841	36.75
Tuwon dawa	1,875	0	Kuka soup	5,711	345.19
Kuka soup	4,834	470.30	Sorrell/spinach soup	139	12.41
Spinach/sorrell/melon soup	105	9.51	Beans	150	0
Pidgeon peas	107	0	Bambara nuts	91	0
Fura	537	0	Sugar cane	420	25.66
Nono	5,114	240.21	Fura	673	0
Groundnut cake		0	Nono	4,714	261.87
Cocoyam	813	49.34	Groundnut cake		0
Cassava, rama	317		Yams	1,601	136.12
Meat	291	0	Meat stew	284	4.00
Garden egg	174	36.34	Kunun Zaki	223	27.96
			Sweet potatoes	173	10.50
			Meat	280	0
Total	788.76		Total	824.76	
Mean	43.82		Mean	45.82	

TABLE 9: TOTAL ASCORBIC ACID INTAKE OF SUB-URBAN CHILDREN AGED FIVE-SEVEN YEARS DURING RAINY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Tea	2,200	0	Bread	758	0	Guinea corn pap	891	
Sugar	201	0	Tea	1,933	0	Bean cake	120	
Milk	67	1.34	Sugar	145	0	Bread	440	
Bread	800	0	Milk	89	1.78	Tea	1,923	
Conflakes	20	0	Oat porridge	150	0	Milk	124	2.4
Maize pap	452	0	Tuwon shinkafa	438	0	Fish stew	89	0.9
Fura	681	0	Bean soup	231	0	Yam pottage	670	21.7
Nono	1,800	70.38	Tuwon dawa	769	0	Tuwon dawa	806	
Boiled maize	173	0	Okro soup	584	112.71	Kuka soup	503	252.7
Boiled groundnuts	261	0	Kuka soup	250	100.9	Tuwon masara	914	
Meat	274	0	Semovita	214	0	Spinach/pumpkin/ sorrell soup	217	222.5
Tuwon masara	564	0	Ayoyo soup	432	42.07	Boiled maize	159	
Kuka soup	397	132.85	Meat	309	0	Roasted groundnuts	87	
Tuwon dawa	472	0	Yam	802	34.16	Buiscuits	68	
Kalkashi soup	945	94.97	Meat stew	315	3.78	Sweets	28	
Pop corn	38	0	Kibena	60	31.42	Semovita	435	
Groundnut	150	0	Sweets	27	0	Ayoyo soup	629	62.2
Guava	52	68.64	Alewa	32	0	Garden egg	84	16.8
Fish	83	0	Fish stew	104	1.29	Guava	56	68.8
Rice with vegetables	350	10.64	Beans	389	0	Fura	400	
Plantain	102	0				Noro	1,607	62.6
Cassava	762	0				Meat	299	
Okro soup	964	186.24						
Total		570.06	Total		328.11	Total		510.97
Mean		71.25	Mean		41.01	Mean		63.87
			Grand Average		61.51			

TABLE 9: (Cnt'd)

FOOD	DAY 4 Wt. (gm)	As. Acid (mg)	FOOD	DAY 5 Wt. (gm)	As. Acid (mg)
Maize	419	0	Tea	2,003	0
Alele	250	0	Bread	412	0
Bean cake	103	0	Sugar	191	0
Fried yam	151	3.14	Milk	100	2.0
Meat stew	80	1.14	Guinea corn pap	533	1.0
Tea	1,234	0	Egg	67	0
Egg	64	0	Bean cake	94	
Sugar	162	0	Fish stew	133	1.35
Milk	102	2.04	Rice	300	0
Bread	384	0	Meat stew	209	3.21
Fried potatoes	199	8.02	Acha pottage	502	6.37
Tuwon shinkafa	764	0	Banana	98	27.44
Okro/pumpkin soup	608	88.16	Yam pottage	703	16.59
Boiled yam	317	13.88	Tuwon dawa	692	0
Orange	248	141.88	Kuka soup	513	152.00
Fish stew	206	2.08	Orange drink	250	98.0
Rice	570	0	Tuwon masara	373	0
Spinach soup	234	24.31	Kalkashi soup	412	47.75
Fura	432	0	Spinach/sorrell melon soup	257	23.49
Nono	2,011	64.35	Roasted maize	191	0
Tuwon dawa	992	0	Garden egg	133	28.40
Kuka soup	584	167.84	Fura	503	0
Roasted maize	302	0	Nono	1,980	70.41
Yam flour	506	0			
Ayoyo soup	703	57.29			
Total		574.10	Total		477.01
Mean		71.76	Mean		59.62

TABLE 10: TOTAL ASCORBIC ACID INTAKE OF SUB-URBAN CHILDREN AGED FIVE-SEVEN YEARS DURING DRY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Tea	1,903	0	Tea	1,284	0	Tea	2,007	0
Milk	142	2.84	Milk	93	1.86	Milk	202	4.04
Sugar	107	0	Sugar	121	0	Sugar	189	0
Bread	578	0	Bread	657	0	Bread	672	0
Irish potatoes	150	7.68	Maize pap	341	0	Guinea corn pap	501	0
Bean cake	100	0	Alele	503	0	Bean cake	126	0
Guinea corn pap	625	0	Egg	214	0	Waina	134	0
Rice	298	0	Tuwon masara	548	0	Banana	189	51.69
Beans	243	0	Spinach/sorrell			Fura	453	0
Meat stew	301	4.24	melon soup	271	24.5	Nono	1,624	35.08
Egg	200	0	Cassava flour	521	0	Groundnut cake		0
Tuwon dawa	498	0	Ayoyo soup	830	89.05	Biscuits	170	0
Kuka soup	279	84.28	Kuka soup	1,241	250.0	Meat	591	0
Semovita	314	0	Tuwon dawa	937	0	Rice	499	0
Okro soup	541	88.29	Meat	303	0	Meat stew	324	4.69
Meat	273	0	Yam pottage	695	13.86	Tuwon acha	529	0
Tuwon shinkafa	548	0	Pounded yam	429	0	Kunun Zaki	281	35.24
Kalkashi soup	629	60.94	Okro soup	525	82.05	Kuka soup	350	71.47
Garden egg	251	50.12	Sugar cane	321	20.99	Kalkashi soup	399	34.13
Tiger nuts	79	0	Meat stew	144	2.03	Garden egg	120	25.07
Sugar cane	708	51.82	Orange drink	280	112.7	Pineapple drink	280	126
Fura	438	0	Peppermint	58	0	Tuwon dawa	602	0
Nono	1,243	38.03	Fura	514	0	Yam flour	453	0
			Nono	1,794	58.82	Ayoyo soup	699	46.37
Total		388.24	Total		651.71	Total		433.78
Mean		48.53	Mean		81.46	Mean		54.22

Grand Average = 55.34

TABLE 10: (Cont·d)

DAY 4 FOOD	Wt. (gm)	As. Acid (mg)	DAY 5 FOOD	Wt. (gm)	As. Acid (mg)
Quaker Oats porridge	207	0	Tea	1,432	0
			Bread	803	0
Milk	192	3.84	Milk	74	1.48
Sugar	174	0	Sugar	124	0
Tea	1,870	0	Egg	51	0
Bread	607	0	Sweet potatoes	214	12.99
Butter	28	0	Meat stew	151	2.96
Fried yam	159	9.73	Guinea corn pap	619	0
Meat stew	243	2.98	Bean cake	133	0
Guinea corn pap	503	0	Sugar cane	461	38.35
Bean cake	99	0	Tuwon masara	533	0
Pop corn	50	0	Kuka soup	684	140.252
Tuwon shinkafa	691	0	Cassava flour	259	0
Kuka soup	501	151.60	Okro soup	350	59.22
Fura	436	0	Bananas	114	30.81
Nono	1,701	47.46	Meat	341	0
Groundnut cake	0		Tuwon dawa	794	0
Meat	892	0	Spinarch/beniseed soup	350	22.12
Sugar cane	521	31.16	Semovita	389	0
Semovita	294	0	Spinach/pumpkin soup	294	41.24
Okro soup	352	51.49	Sweets	68	0
Pounded yam	160	0	Kalkashi soup	602	50.98
Spinach/melon soup	175	12.30			
Tuwon dawa	529	0			
Pumpkin/okro soup	308	29.14			
Total	339.69		Total	400.40	
Mean	42.46		Mean	50.05	

TABLE 11: TOTAL ASCORBIC ACID INTAKE OF URBAN CHILDREN AGED FIVE-SEVEN YEARS DURING RAINY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Yams	705	28.62	Guinea corn pap	570	0	Fried Irish potatoes	294	11.92
Meat stew	343	4.86	Alele	293	0	Salmon fish	60	0
Meat	1,641	0	Millet pap	498	0	Fish stew	201	1.20
Tea	1,739	0	Bean cake	122	0	Tea	1,8	
Bread	583	0	Tea	2,014	0	Egg	139	0
Sugar	179	0	Bread	836	0	Bread	901	0
Milk	129	2.58	Sugar	157	0	Milk	214	4.28
Maize pap	653	0	Milk	107	2.14	Sugar	198	0
Bean cake	134	0	Pineapple drink	213	164.41	Guinea corn pap	643	0
Waina	143	0	Boiled maize	607	0	Bean cake	141	0
Tuwon masara	638	0	Plantain	257	0	Tuwon dawa	928	0
Melon/bitterleaf soup	480	38.59	Rice	839	0	Kuka soup	2,483	344.9
			Meat stew	413	5.82	Groundnut cake		0
Kalkashi soup	450	54.13	Cassava flour	924	0	Yam pottage	633	16.71
Yam flour	537	0	Okro soup	633	129.82	Semovita	487	0
Ayoyo soup	531	54.03	Tuwon shinkafa	791	0	Okro soup	431	86.2
Boiled maize	602	0	Kalkashi soup	574	69.17	Cassava/zogale/ groundnut	209	25.72
Tuwon dawa	834	0	Tuwon dawa	643	0	Fura	598	0
Kuka soup	604	121.65	Kuka soup	508	103.73	Nono	1,944	80.0
Guava	130	172	Meat	38	0	Boiled maize	408	0
Yam pottage	298	6.37	Fura	614	68.37	Tuwon masara	994	0
Meat	411	0	Nono	1,894	68.37	Spinach/sorrell melon soup	350	31.78
						Orange	102	57.84
						Meat	294	0
Total	784.16		Total	720.59		Total	748.67	
Mean	60.35		Mean	55.43		Mean	57.59	

Grand Average = 53.6

TABLE 11: (Cont'd)

DAY 4 FOOD	Wt. (gm)	As. Acid (mg)	DAY 5 FOOD	Wt. (gm)	As. Acid (mg)
Waina	243	0	Tea	2,132	0
Tea	1,938	0	Milk	154	3.08
Bread	843	0	Sugar	190	0
Milk	129	2.58	Bread	729	0
Sugar	148	0	Butter	21	0
Egg	134	0	Rice	679	0
Pancake	204	0	Beans	384	0
Maize pap	469	0	Guinea corn pap	748	0
Bean cake	138	0	Bean cake	199	0
Tuwon masara	899	0	Boiled maize	294	0
Kuka soup	1,438	332.45	Tiger nuts	114	0
Tuwon dawa	1,012	0	Tuwon dawa	997	0
Roasted maize	482	0	Kuka soup	1,389	378.56
Groundnuts	305	0	Irish potatoes	178	10.80
Biscuits	143	0	Spinach soup	438	28.86
Bananas	109	29.81	Meat	214	0
Fura	485	0	Orange drink	257	113.38
Nono	1,843	75.93	Tuwon shinkafa	894	0
Yam flour	749	0	Kalkashi soup	432	56.42
Ayoyo soup	537	35.27	Pounded yam	601	0
Acha pottage	465	5.44	Spinach/melon soup	375	26.4
Garden egg	248	40.6	Cassava flour	534	0
Meat	200	0	Spinach/beniseed soup	334	23.51
			Garden egg	124	26.04
Total	571.44		Total	661.44	
Mean	43.88		Mean	50.88	

TABLE 12: TOTAL ASCORBIC ACID INTAKE OF URBAN CHILDREN AGED FIVE-SEVEN YEARS DURING DRY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Guinea corn pap	424	0	Tea	1,342	0	Tea	894	0
Alele	489	0	Bread	814	0	Eggs	42	0
Bean cake	137	0	Sugar	143	0	Milk	154	3.08
Tea	1,348	0	Fish stew	234	2.387	Sugar	134	0
Sugar	124	0	Milk	172	3.44	Bread	769	0
Milk	193	3.86	Maize pap	638	0	Sweet potatoes	263	10.59
Bread	870	0	Bean cake	194	0	Meat stew	154	2.17
Plantain	413	12.43	Millet pap	250	0	Guinea corn pap	509	0
Fried sweet potatoes	346	6.95	Alele	338	0	Alele	298	0
Pounded yam	250	0	Rice	607	0	Bean cake	172	0
Okro soup	359	31.5	Meat stew	143	2.016	Meat	402	0
Semovita	503	0	Tuwon dawa	892	0	Tuwon dawa	824	0
Ayoyo soup	452	25.96	Kuka soup	674	173.14	Kuka soup	1,509	426.95
Cassava flour	573	0	Tuwon masara	743	0	Tuwon masara	749	0
Spinach/melon soup	298	19.13	Okro soup	523	49.03	Spinach/melon bitterleaf soup	700	44.94
Meat	328	0	Yam flour	448	0	Fura	850	0
Sugar cane	644	41.28	Kalkashi soup	537	28.59	Nono	1,843	68.37
Fura	512	0	Beans	249	0	Sugar cane	429	13.38
Nono	1,649	49.52	Tiger nuts	71	0	Rice	893	0
Tuwon dawa	738	0	Sugar cane	602	36.78	Fish stew	324	3.27
Kuka	3,750	324.5	Nono	4,550	335.95	Groundnuts	250	0
						Cassava flour	741	0
						Okro soup	602	111.97
Total		510.38	Total		521.95	Total		625.17
Mean		39.26	Mean		40.15	Mean		48.09

Grand Average 44.45

TABLE 12: (Cont'd)

DAY 4 FOOD	Wt. (gm)	As. Acid (mg)	DAY 5 FOOD	Wt. (gm)	As. Acid (mg)
Waina	402	t	Tea	1,780	t
Dan-wake	133	t	Bread	920	t
Guinea corn pap	634	0	Milk	145	2.9
Bean cake	154	0	Sugar	143	t
Tea	1,423	t	Fish stew	155	1.56
Sugar	158	0	Egg	149	t
Milk	102	2.04	Maize pap	614	t
Egg	199	0	Bean cake	203	t
Pancake	132	t	Semovita	800	t
Bread	674	0	Okro soup	450	86.85
Pounded yam	589	t	Jollof rice	678	14.17
Bean soup	499	4.44	Rice & Beans	594	t
Yam pottage	702	15.02	Tuwon dawa	913	t
Fura	793	0	Kuka soup	2,448	312.58
None	1,492	52.82	Groudnut cake		t
Rice	694	t	Sugar cane	312	19.18
Meat stew	193	2.72	Cassava flour	549	0
Tuwon dawa	941	0	Kalkashi soup	1,421	157.34
Kuka soup	3,621	329.47	Spinach/melon soup	150	9.63
Semovita	534	0			
Ayoye soup	629	43.96	Tuwon shinkafa	638	t
Tuwon masara	830	t	Spinach/serrell		
Kalkashi soup	570	38.68	melon soup	374	33.84
Okro/pumpkin soup	384	47.5	Fura	902	0
Sugar cane	714	29.4	None	1,483	53.53
Garden egg	291	30.79	Meat	420	t
Meat	234	0			
Total	596.05		Total	636.22	
Mean	45.85		Mean	48.94	

TABLE 13: TOTAL ASCORBIC ACID INTAKE OF RURAL ADULTS AGED 55 - 72 YEARS DURING RAINY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Guinea corn pap	1,938	0	Guinea corn pap	1,724	0	Maize pap	639	0
Bean cake	400	0	Bean cake	374	0	Millet pap	820	0
Fura	225	0	Tuwon dawa	330	0	Bean cake	362	0
Nono	1,900	332.58	Kalkashi soup	225	29.78	Tuwon shinkafa	398	0
Yam	339	13.62	Okro soup	718	139.148	Kuka soup	1,500	411.77
Tuwon dawa	549	0	Kolanut	421	82.91	Cocoyam	433	13.25
Tuwon masara	531	0	Tuwon masara	507	0	Meat stew	207	2.11
Kuka soup	1,494	456.84	Fura	660	0	Tuwon dawa	564	0
Okro soup	438	77.43	Nono	1,850	126.61	Okro soup	624	63.96
Kolanut	184	27.96	Fish	1,003	0	Kolanut	330	54.39
Groundnut	151	0				Fish	729	0
Meat	809	0						
Total	907.27		Total	377.72		Total	545.09	
Mean	129.61		Mean	53.96		Mean	77.87	
			Grand Average	75.22				

TABLE 13: (Cont'd)

DAY 4 FOOD	Wt. (gm)	As. Acid (mg)	DAY 5 FOOD	Wt. (gm)	As. Acid (mg)
Guinea corn pap	1,389	0	Guinea corn pap	984	0
Bean cake	424	0	Maize pap	940	0
Cassava, zogala & groundnut	327	33.71	Bean cake	394	0
			Waina	120	0
Kolanut	94	15.97	Dan-wake	147	0
Tuwon dawa	654	0	Tuwon shinkafa	334	0
Boiled groundnuts	138	0	Spinach/pumpkin soup	280	25.06
Kalkashi soup	1,354	143.77	Boiled maize	125	0
Fura	239	0	Tuwon dawa	500	0
Nono	1,624	65.84	Kuka soup	900	427.57
Okro	451	79.31	Kolanut	75	14.47
Total		335.37	Total		467.52
Mean		47.91	Mean		66.78

TABLE 14: TOTAL ASCORBIC ACID INTAKE OF RURAL ADULTS AGED 55 - 72 YEARS DURING DRY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Bean cake	388	0	Yam	147	6.35	Guinea corn pap	1,983	0
Maize pap	1,075	0	Meat stew	93	0.93	Bean cake	429	0
Tuwon dawa	631	0	Bean cake	426	0	Kolanut	207	40.49
Kuka soup	924	198.53	Maize pap	1,029	0	Fura	1,000	0
Yam pottage	182	2.75	Kolanut	379	42.92	Nono	2,800	120.16
Kolanut	514	70.51	Tuwon masara	940	0	Tuwon dawa	500	0
Okro soup	160	8.86	Kalkashi soup	450	20.33	Kuka soup	823	178.65
Spinach/melon soup	374	27.19	Groundnuts	153	0	Okro soup	461	16.82
Meat	605	0	Zogala & G/nut	203	3.06			
Fish	24	0	Meat	922	0			
Fura	123	0	Tuwon dawa	739	0			
Nono	961	31.23	Okro soup	502	24.89			
			Kuka soup	1,238	163.14			
Total		336.14	Total		261.87	Total		352.03
Mean		48.02	Mean		37.41	Mean		50.29
			Grand Average		44.70			

TABLE 14: (Cont'd)

FOOD	DAY 4 Wt. (gm)	As. Acid (mg)	FOOD	DAY 5 Wt. (gm)	As. Acid (mg)
Guinea corn pap	1,839	0	Maize pap	1,620	0
Bean cake	269	0	Bean cake	354	0
Kolanut	624	100.62	Garden egg	59	12.03
Sweet potatoes	339	19.25	Kolanut	483	123.58
Meat stew	103	1.03	Fura	499	0
Tuwon shinkafa	550	0	Nono	1,005	32.76
Okro soup	1,480	80.93	Tuwon dawa	528	0
Kalkashi soup	891	64.59	Kuka soup	984	160.72
Tuwon dawa	334	0	Okro soup	398	12.14
Total	265.93		Total	348.00	
Mean	37.99		Mean	49.8	

TABLE 15: TOTAL ASCORBIC ACID INTAKE OF SUB-URBAN ADULTS AGED 55 - 72 YEARS DURING RAINY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Tea	1,849	0	Maize	429	0	Irish potatoes	250	10.52
Sugar	75	0	Guinea corn pap	834	0	Meat stew	244	2.40
Bread	500	0	Alele	250	0	Bread	329	0
Sweet potatoes	150	9.55	Tea	1,007	0	Tea	1,240	0
Milk	87	1.74	Bread	302	0	Milk	90	1.8
Meat stew	102	1.05	Milk	79	1.08	Sugar	94	0
Fura	225	0	Eggs	67	0	Yam	244	9.50
Nono	450	46.02	Meat stew	134	1.42	Boiled maize	179	0
Maize mold	200	0	Rice and Beans	399	0	Fura	280	0
Spinach/melon soup	194	11.03	Yam flour	289	0	Noro	902	49.22
Tuwon dawa	250	0	Ayoyo soup	255	47.08	Tuwon shinkafa	503	0
Kuka soup	225	46.26	Tuwon dawa	680	0			
Cassava flour	201	0	Kalkashi soup	509	80.31	Kalkashi soup	439	80.53
Okro soup	334	42.38	Okro/pumpkin soup	259	11.04	Tuwon acha	389	0
Boiled groundnut	200	0	Kolanut	60	11.04	Kuka soup	175	35.24
Kolanut	28	4.85	Meat	214	0	Rice	320	0
Meat	113	0	Fish	604	0	Fish stew	124	1.24
			Sugar	83	0	Fish	309	0
						Meat	720	0
Total	162.88		Total	152.83		Total	191.94	
Mean	40.72		Mean	38.20		Mean	47.98	

Grand Average 44.33

TABLE 15: (Cont'd)

DAY 4 FOOD	Wt. (gm)	As. Acid (mg)	DAY 5 FOOD	Wt. (gm)	As. Acid (mg)
Bread	174	0	Tea	1,289	0
Guinea corn pap	827	0	Sugar	104	0
Bean cake	259	0	Milk	120	2.4
Semovita	254	0	Bread	439	0
Spinach/melon soup	229	12.89	Maize pap	601	0
Milk	81	1.62	Alele	490	0
Tea	994	0	Garden egg	234	45.58
Sugar	71	0	Boiled maize	159	0
Tuwon dawa	683	0	Rice & beans	484	0
Kuka soup	325	85.09	Meat stew	304	4.22
Cassava, zogala & g/nut	584	11.85	Tuwon dawa	559	0
Yam flour	294	0	Okro soup	416	76.29
Okro soup	259	64.08	Yam pottage	208	4.43
Kolanut	50	8.19	Fura	220	0
Meat	101	0	Nono	505	56.40
			Meat	98	0
Total	183.72		Total	189.33	
Mean	45.93		Mean	47.33	

TABLE 16: TOTAL ASCORBIC ACID INTAKE OF SUB-URBAN ADULTS AGED 55 - 72 YEARS DURING DRY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Tea	1,073	0	Guinea corn pap	481	0	Sweet potatoes	200	12.46
Sugar	79	0	Alele	252	0	Maize pap	581	0
Milk	39	0	Tea	949	0	Sugar	59	0
Bread	259	0	Bread	107	0	Jollof rice	189	0
Maize pap	684	0	Milk	28	0.56	Yam flour	200	0
Bean cake	203	0	Sugar	64	0	Okro soup	350	53.23
Alele	150	0	Fura	552	0	Cassava flour	180	0
Rice and beans	324	0	Nono	1,009	32.69	Spinach/melon soup	162	8.76
Meat stew	214	3.38	Cassava flour	279	0	Fura	458	0
Meat	256	0	Okro soup	179	34.65	Nono	1,005	39.99
Tuwon dawa	750	0	Tuwon dawa	500	0	Yam pottage	287	6.14
Okro soup	530	68.83	Kuka soup	509	149.49	Roasted groundnut	129	0
Semovita	279	0	Roasted g/nut	150	0	Kolanuts	75	13.20
Ayoyo soup	177	18.16	Bean cake	200	0	Meat	200	0
			Meat	139	0			
Total	91.15		Total	217.39		Total	135.68	
Mean	22.78		Mean	54.34		Mean	33.92	
				Grand Average	35.78			

TABLE 16: (Cont'd)

FOOD	DAY 4 Wt. (gm)	As. Acid (mg)	FOOD	DAY 5 Wt. (gm)	As. Acid (mg)
Guinea corn pap	872	0	Maize pap	1,324	0
Sugar	69	0	Tea	925	0
Bean cake	309	0	Bread	234	0
Bread	254	0	Sugar	82	0
Tea	829	0	Beans	164	0
Milk	64	1.28	Boiled cassava + zegala	203	24.42
Tuwon dawa	629	0	Kolanuts	74	12.26
Kuka soup	359	101.14	Milk	62	1.24
Rice	348	0	Tuwon shinkafa	629	0
Meat stew	141	1.43	Okro soup	441	36.86
Semovita	299	0	Tuwon dawa	552	0
Ayoyo soup	341	25.21	Kuka soup	329	67.14
Meat	194	0	Eggs	109	0
			Meat	82	0
Total	129.66		Total	141.92	
Mean	32.41		Mean	35.48	

TABLE 17: TOTAL ASCORBIC ACID INTAKE OF URBAN ADULTS AGED 55 - 72 YEARS DURING RAINY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Waina	132	0	Maize	697	0	Guinea corn pap	409	0
Tea	1,834	0	Bean cake	300	0	Bean cake	384	0
Bread	342	0	Tea	453	0	Maize pap	833	0
Sugar	99	0	Bread	124	0	Sweet potatoes	344	1.98
Milk	71	1.42	Sugar	101	0	Yams	374	15.18
Tuwon shinkafa	309	0				Meat stew	211	2.59
Kalkashi soup	251	40.28	Meat stew	211	2.13	Cassava/zogala/g-nut	179	22.12
Tuwon dawa	417	0	Tuwon acha	259	0	Boiled groundnuts	99	0
Kuka soup	1,381	297.00	Spinach/sorrell/ melon soup	297	44.88	Fura	228	0
Semovita	174	0	Boiled groundnuts	125	0	Nono	500	18
Okro soup	209	35.95	Kolanuts	70	12.6	Yam flour	271	0
Maize mould	194	0	Fura	531	0	Okro soup	208	42.47
Alele	254	0	Nono	1,007	39.67	Tuwon dawa	550	0
Meat	299	0	Tuwon dawa	219	0	Kuka soup	1,914	332.60
Meat stew	233	3.12	Kalkashi soup	1,227	129.57	Meat	174	0
Total	377.46		Total	228.96		Total	434.79	
Mean	41.94		Mean	25.44		Mean	48.31	

Grand Average 36.57

TABLE 17: (Cont'd)

FOOD	DAY 4 Wt. (gm)	As. Acid (mg)	FOOD	DAY 5 Wt. (gm)	As. Acid (mg)
Dan-wake	154	0	Guinea corn pap	098	0
Maize pap	894	0	Bean cake	501	0
Bean cake	402	0	Millet pap	459	0
Tea	643	0	Fura	289	0
Bread	101	0	Nono	526	20.72
Sugar	92	0	Kolanuts	79	14.52
Milk	36	0.72	Semovita	216	0
Fura	275	0	Okro soup	1,284	143.36
Nono	514	15.52	Tuwon dawa	405	0
Maize mould	179	0	Kalkashi soup	917	150.40
Alele	294	0	Okro/pumpkin soup	229	6.92
Cassava flour	251	0	Yam pottage	544	10.83
Ayoyo soup	250	25.72	Meat	189	0
Tuwon masara	500	0			
Spinach/melon soup	154	9.73			
Tuwon dawa	299	0			
Kuka soup	904	179.22			
Meat	241	0			
Kolanut	64	17.65			
Total	248.76		Total	352.89	
Mean	27.64		Mean	39.21	

TABLE 18: TOTAL ASCORBIC ACID INTAKE OF URBAN ADULTS AGED 55 - 72 YEARS DURING DRY SEASON

DAY 1 FOOD	Wt. (gm)	As. Acid (mg)	DAY 2 FOOD	Wt. (gm)	As. Acid (mg)	DAY 3 FOOD	Wt. (gm)	As. Acid (mg)
Sweet potatoes	384	23.08	Tea	2,421	0	Millet pap	677	0
Guinea corn pap	403	0	Sugar	79	0	Guinea corn pap	942	0
Sugar	89	0	Bread	341	0	Milk	24	0.48
Bean cake	205	0	Milk	88	1.76	Sugar	99	0
Fura	214	0	Maize pap	519	0	Tea	741	0
Nono	492	14.81	Bean cake	300	0	Guinea corn	366	28.27
Rice and beans	438	0	Pounded yam	379	0	Tuwon acha	289	0
Meat stew	217	2.21	Spinach/melon soup	500	34.9	Spinach/sorrell/ melon soup	244	14.56
Tuwon dawa	294	0	Yam flour	234	0	Fura	236	0
Kuka soup	825	159.62	Okro soup	569	128.64	Nono	450	14.67
Tuwon masara	279	0	Tuwon dawa	250	0	Semovita	231	0
Okro soup	504	66.68	Kalkashi soup	179	32.56	Ayoyo soup	225	24.18
Meat	2,329	0	Fura	284	0	Meat	1,784	0
Kolanut	51	8.98	Nono	607	18.33	Kolanut	364	62.50
			Meat	1,899	0	Tuwon dawa	189	0
						Kuka soup	837	154.89
Total		275.31	Total		216.45	Total		281.52
Mean		30.59	Mean		24.05	Mean		31.28
			Grand Average		33.205			

TABLE 18: (Cont'd)

FOOD	DAY 4 Wt. (gm)	As. Acid (mg)	FOOD	DAY 5 Wt. (gm)	As. Acid (mg)
Waina	128	0	Maize pap	873	0
Tea	613	0	Yam pottage	233	4.68
Sugar	79	0	Alele	459	0
Milk	24	0.48	Guinea corn pap	924	0
Bread	194	0	Bean cake	202	0
Dan-wake	132	0	Sweet potatoes + G-nut oil	354	20.11
Banana	80	21.88	Garden egg	109	21.46
Cocoyam/G-nut oil	281	15.98	Yam flour	214	0
Meat stew	194	2.33	Okro soup	609	52.04
Tuwon dawa	257	0	Tuwon shinkafa	254	0
Okro soup	225	91.63	Kuka soup	1,298	270.48
Rice and Beans	214	0	Fura	250	0
Tuwon masara	459	0	Nono	900	27.0
Kalkashi soup	1,683	192.27	Meat	943	0
Fish	254	0			
Meat	1,849	0			
Total		325.44	Total		395.13
Mean		36.16	Mean		43.9

TABLE 19: ASCORBIC ACID CONTENT OF SELECTED VEGETABLE IN 1976/77 PLANTING YEAR

VEGETABLE		ASCORBIC ACID CONTENT (mg/100g)	
Local Name	Botanical Name	Rainy Season	Mean
Pumpkin	Curcubita pepo	51, 54, 58, 60, 39, 42.2 62.8 64, 66.3, 52.7	55.0
Spinach	Amaranthus candatus	68.6, 91, 60, 68, 63, 75 61, 64, 58, 65	67.36
Bitterleaf	Vernonia amygalina	60, 78.9, 52, 65.1, 63 45.1, 47.4, 79.6, 89.7, 71.3	65.21
Sorrell leaves	Hibiscus sabdariffa	61, 89, 34.3, 73.6, 29.1 62, 67, 88, 48 67.4	61.94
Tomatoes	Lycospersium esculentum	100.6, 98.4, 99, 85, 91, 69, 77.8, 75.2 80	89.02
Red peppers	Capsicum spp	150, 134.7, 168.3, 128, 173, 145, 152.6, 154.4, 149, 173.7	152.07
Okro	Hibiscus esculentus	70, 79, 59, 37, 57, 44 62, 70, 59.7, 50.4	58.81
"Kalkashi"	Corchorus spp	54.5, 56, 63.5, 41, 58	56.02
"Yalo"	Solanum elongeana	22.5, 32, 30.6, 38 32.4, 18, 49, 41, 19 32	31.45

TABLE 19: (Cont'd)

VEGETABLE		ASCORBIC ACID CONTENT (mg/100g)	
Local Name	Botanical Name	Dry Season	Mean
Pumpkin	Curcubita spp	53.4, 54.8, 56.2, 41, 28, 60, 67.4, 34.6, 40 45.	48.04
Spinach	Amaranthus candatus	41, 84, 123.1, 84, 72.9, 70, 92.5, 54, 60.5, 89, 78	72.50
Bitterleaf	Vernonia amygalina	69.4, 74, 59, 62.7, 57, 58.2, 48.6, 34, 75.4, 55	59.34
Sorrell leaves	Hibiscus sabdariffa	70.3, 45, 66, 33, 49, 58, 54.5, 60.5, 61, 75	57.20
Tomatoes	Lycospersium esculentum	96.4, 112.8, 79, 84, 64, 99, 80, 85, 89, 94.3	88.35
Red peppers	Capsicum spp	110, 137.1, 100.9, 94, 145, 164, 89, 97, 124 68.8	112.98
Okro	Hibiscus esculentum	22.7, 49, 40, 37, 54, 56, 32, 48, 58, 45	44.17
Kalkashi	Corchorus spp	42.6, 40, 48.9 46.1, 30.4, 63.6, 31, 68, 45, 70	48.56
Yalo	Solanum melengeana	25, 22, 30.8, 27, 24.2, 29.1, 35, 22.9 34, 16.4	26.64

TABLE 20: ASCORBIC ACID CONTENT OF SELECTED VEGETABLES IN 1977/78 PLANTING YEAR

VEGETABLE		ASCORBIC ACID CONTENT (mg/100g)	
Local Name	Botanical Name	Rainy Season	Mean
Pumpkin	Curcubita pepo	41, 42.7, 54, 63.3, 48, 50, 66.9, 84, 27.1, 25	50.2
Spinach	Amaranthus candatus	70.4, 75, 81.0, 83, 68.7 74, 91, 84, 76, 52	75.54
Bitterleaf	Vernonia amygalina	74.9, 67, 65.1, 59, 84, 72, 79, 83, 68, 54.5	70.55
Sorrell leaves	Hibiscus sabdariffa	59.2, 63.0, 64.2, 54, 68.8, 79.4 73, 40.6, 51, 68	62.12
Tomatoes	Lycospersium esculentum	101.6, 79.2, 84, 78.4 80.6, 90, 81, 64, 72, 68	79.82
Red peppers	Capsicum spp	174.3, 184, 174, 186.7, 176, 159.1, 195, 171, 180, 106	170.61
Okro	Hybiscus esculentum	63.1, 60.0, 59, 69.3, 64, 68.7, 43, 74.1, 64.9, 60	62.81
Kalkashi	Corchorus spp	50.4, 55.8, 51.0, 54, 49 60, 44, 43, 71, 43.6	52.18
Yalo	Solanum melongeana	27.5, 24, 25, 30, 29, 31, 29, 28, 26, 36	27.55

TABLE 20: (Cont'd)

VEGETABLE		ASCORBIC ACID CONTENT (mg/100g)	
Local Name	Botanical Name	Dry Season	Mean
Pumpkin	Curcubita pepo	28, 24, 66.2, 79, 56.8, 65, 50, 41, 43.8, 51.2	50.00
Spinach	Amaranthus candatus	47, 52, 61, 58.1, 71, 57.9, 59, 70.2 65.8, 60	60.40
Bitterleaf	Vernonia amygalina	65.4, 61.3, 81.7, 84, 77, 70, 69, 68, 82, 34	69.24
Sorrell leaves	Hibiscus sabdariffa	51.7, 50, 45, 48.6, 64 61.4, 66, 52.7, 40, 34.0	51.37
Tomatoes	Lycospersium esculentum	77.5, 79, 89, 65, 94, 63, 81, 75, 77, 57	75.75
Red peppers	Capsicum spp	130.2, 120, 128, 142.7, 154.3, 116, 117.4 133.6, 155, 75	127.22
Okro	Hybiscus esculentum	40, 42.5, 34, 38.6, 49.4 49, 51.7, 39, 35.3, 32	41.05
Kalkashi	Corchorus spp	49.6, 54.2, 37, 44, 49, 50, 51, 59, 58, 49	50.88
Yalo	Solanum melongeana	27.8, 29, 31, 25, 27, 32, 30, 24, 26, 31	28.28

GLOSSARY OF FOOD TERMS IN HAUSA

HAUSA NAME	ENGLISH TRANSLATION
Kunun zaki	Fermented porridge made from coarse siftings of guinea corn.
Fura	Cooked millet balls.
Nono	Soured milk
Dan-wake	Hausa dumplings made from bean flour.
Tuwon dawa	Guinea corn porridge hardened into a mold.
Koko	Porridge.
Kunu	Porridge.
Kosai	Fried bean cakes.
Alele	Steamed bean cake.
Miyan taushe	Vegetable/pumpkin soup.
Miyan kuka	Baobab leaf soup.
Waina	Pancake
Tuwon masara	Maize porridge hardened into a mold.
Tuwon shinkafa	Rice porridge hardened into a mold.
Alkaki	Wheat puff-puff.

RECIPES FOR PREPARATION OF COMMON FOODS

PECULIAR TO THE SURVEY POPULATION

TUWON SHINKAFA

Rice

Water

1. Cook dehulled raw rice in boiling water until soft. It should be very slightly stick but break apart fairly easily into separate grains.
2. Serve by just scooping it from the pot and cover with vegetable soup.

TUWON DAWA

3 cups of water

1½ cups of guinea corn flour.

1. Pound or mill guinea corn grain into flour.
2. Sift to remove any shaft.
3. Boil 2½ cups of water in a pot.
4. Mix ½ cup sifted flour with ¾ cup of water into a thin paste.
5. Pour the paste into the boiling water and stir vigorously for 2 minutes. Allow to boil for 7 minutes.

7. Scoop with a small piece of calabash and serve with vegetable soup.

Tuwon gero and masara are made in exatly the same way with millet flour or maize flour.

KUNU

Guinea corn or millet

Hot dried pepper

Dried ginger

Potash, sweet potato flour

1. Sift guinea corn or millet flour.
2. Boil some water with a little potash.
3. Put a little flour in a calabash, and sprinkle with a little water. Form into little balls. Drop these balls into boiling water and cook until they are just done.
4. Mix the remaining grain flour with a little cold water to make a thick paste.
5. When the balls are done, pour the boiling water with the balls into the flour mixture and stir well. Cook until thick.
6. Cool the Kunu and add sweet potato flour.

WAINA

6 ozs rice flour
2 oz granules of rice flour
A pinch of salt
A pinch of onion
A pinch of potash
3 desertspoonful of sour milk
Groundnut oil for frying

1. Mix rice flour granules, chopped onions and salt in a mixing bowl.
2. Add boiling water into the mixture and stir. Leave to cool.
3. Add the rice flour gradually and mix into a soft paste. Add the sour milk and mix.
4. Cover up and leave in a warm place overnight.
5. In the morning add some water to make the paste into batters and add potash to neutralise the acidic taste.
6. Grease the local waina frying pan with some groundnut oil.
7. Heat the frying pan and pour the batter in spoonfuls.
8. When the waina sets, use a palate knife to loosen the edges and turn the product over.
9. When loosening the edges, brush with more oil.
10. When done, serve hot with stew, sauce or honey.

KUNUN ZAKI

Guinea corn

Sweet potato flour

1. Soak guinea corn in cold water for 2 days.
2. Clean and wet mill.
3. Add boiling water to guinea corn paste, cook until thick.
4. Dissolve sweet potato flour in water to make a paste.
5. Add sweet potato paste to cooked guinea corn paste.
6. Cool mixture and sift with fine cloth or fine meshed sift. Discard the shaft.
7. Put Kunun Zaki in bottle, cool and drink.

KUKA SOUP

Baobab leaves, dried

Locust bean cakes

Salt

Palm oil or groundnut oil or butter

Tomatoes

Onions

Peppers

Meat or fish

Potash

Ginger dried.

1. Fry meat, tomatoes, onions, peppers in oil.

2. Add water, potash, meat, locust bean cake, ginger and salt. Cook until meat is done.
3. Add powdered baobab leaves and cook for another ten minutes.
4. Serve with tuwo.

NONO

Fresh cow's milk
Fruit of the baobab tree

1. Pour fresh cow's milk into a calabash. If it is cold season, cover the calabash and place it in a corner of the room. If it is hot season, leave the calabash uncovered.
2. Leave the milk to sit without stirring for 24 hours.
3. Skim the thickened cream from the top and place it in another calabash.
4. Beat the skimmed milk until it is smooth.
5. Soak the white interior of the baobab seed in water until the white is dissolved in the water. Strain the whitened soaking water into the skimmed milk and beat again.

FURA

Millet or guinea corn
Black pepper, ginger, hot dried pepper
Potash (optional)

1. Prepare flour from grain either by home pounding or milling.
2. Boil water in a large container and add potash if desired.
3. Dampen the flour with water and mould into balls. Drop the balls into the boiling water.
4. Cook for 20 minutes.
5. Pour off most of the liquid into a calabash and reserve.
6. Pour the cooked balls and some of the reserved water into a wooden mortar and break up the balls with a pestle. Add the desired spices.
7. Pound the mixture until a coherent smooth, slightly elastic lump is formed.
8. Mould the Fura into smooth balls.
9. To serve, crush Fura balls with hand or spoon, pour nono over it and mash the balls thoroughly into the liquid, leaving only a few small chunks of fura in the liquid. Drink immediately.

DAN-WAKE

1 cup Bean fleur
½ cup cassava, dried
Salt and pepper to taste
2 teaspoon potash water
2 tablespoon groundnut oil

1. Sieve beans and cassava flour together in a bowl.
2. Mix with potash water to a smooth paste.
3. Shape the mixture into small balls. Drop the balls into boiling water.
4. Cook until done.
5. Drain water when cooled, add groundnut oi, salt and pepper.

HOSPITALS AND OTHER MEDICAL CENTRES SURVEYED FOR CLINICAL SCURVY

University Teaching Hospitals

1. Ahmadu Bello University Hospital, Kaduna.
2. Ahmadu Bello University Hospital, Zaria.
3. Ahmadu Bello University Hospital, Malumfashi.

Military Hospitals

4. 44 Armed Forces Hospital, Kaduna.
5. Air Force Base Hospital, Kano.

Specialist Hospitals

6. Orthopaedic Hospital, Kano.
7. Guiness Eye Hospital, Kaduna.

Government General Hospitals

8. Murtala Mohammed Hospital, Jos.
9. General Hospital, Vom.
10. General Hospital, Bauchi.
11. General Hospital, Katsina.
12. General Hospital, Daura.
13. S. I. M. Hospital, Kagoro.
14. General Hospital, Minna.
15. General Hospital, Bida.
16. General Hospital, Funtua.
17. General Hospital, Gusau.
18. General Hospital, Barkin Ladi.

Private Clinics

19. Ande Hospital, Jos.
20. Lafia Clinic, Kaduna.
21. Judah Clinic, Jos.
22. Unity Clinic, Minna.
23. Jankwanu (Evangel) Hospital, Jos.
24. Mayfair Clinic, Zaria.
25. Alma Clinic, Kaduna.

Rural Health Centres

26. Rural Health Centre, Kwoi.
27. Islamiya Clinic, Bukuru.
28. Rural Centre Nasarawa Eggon.
29. Rural Health Centre, Duchin-Wai.
30. Rural Health Centre, Biu.
31. Rural Health Centre, Kuta.
32. Rural Health Centre, Bagana.
33. Rural Health Centre, Abaji Kolo.
34. Health Centre, Kafanchan.
35. Health Centre, Dutsin-Wai.

Maternity Hospitals

36. Maternity Hospital, Jos.
37. Maternity Health Centre - Abaji Kolo.
38. Maternity Clinic, Biu.
39. Maternity Clinic, Minna.
40. Maternity/Child Health Clinic, Dutsin-Mai.
41. Maternity Clinic, Birnin-Gwari.

SEASONAL AVAILABILITY OF DIETARY ASCORBIC ACID (VITAMIN C) IN ZARIA DISTRICT OF KADUNA STATE, NIGERIA

By

ADENIKE ADEJOKE ADDO

B.Sc., University of Ibadan, Nigeria, 1970

M.Sc., Kansas State University, U.S.A., 1973

AN ABSTRACT OF THESIS

Submitted in partial fulfillment

of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Biochemistry

Faculty of Science

Ahmadu Bello University

ZARIA, NIGERIA

April, 1980

Seasonal availability of dietary ascorbic acid (Vitamin C) was studied in Zaria district of Kaduna State, Nigeria. The diet of a selected population during dry and rainy seasons was studied. Dietary ascorbic acid was determined by chemical analysis of food consumed. The population studied included people from various tribes of the country resident in the urban, sub-urban and rural areas of Zaria district.

The effects of traditional method of cooking, reheating and storage of vegetable soups were investigated. Bioavailability of ascorbic acid from "kuka" soup was studied in six adults. The effect of sun-drying and storage on the retention of ascorbic acid of common vegetables was also evaluated.

Results showed that vegetables constituted the major source of ascorbic acid because of low consumption of fruits. Ascorbic acid contents of the vegetables commonly consumed ranged from 38.6mg/100g in water leaf to 149.1mg/100g in red peppers. Fresh vegetables provided adequate ascorbic acid during rainy season while stored dehydrated vegetables provided the necessary ascorbic acid during the dry season. The consumption of dry season fruits such as mangoes, garden egg and carrots supplemented the ascorbic acid intake from stored dehydrated vegetables.

The mean daily ascorbic acid intake of children two to four years old was 34.6mg in the dry season and 48.6mg in the rainy season. The mean daily ascorbic acid intake of children five to seven years old was higher in the rainy season (64.7mg) than in the dry season (46.9mg). Similarly among the aged people, the mean daily ascorbic acid intake was higher during the rainy season (51.9mg) than in the dry season (37.8mg). Total ascorbic acid intake was significantly ($P < 0.05$) affected by season and location. Plasma ascorbic acid level of six adult volunteers on regular diet ranged from 0.63 to 1.14mg%, urinary ascorbic acid excretion in the same subjects also ranged from 31.3 to 106.4mg/g creatinine. Treatment of subjects with 60mg ascorbic acid from "kuka" soup increased the plasma ascorbic acid by 35.9% while similar supplementation with ascorbic acid tablet increased the plasma ascorbic acid by 91.0% Urinary excretion of ascorbic acid was also increased by supplementation of 60mg ascorbic acid. Availability from "kuka" soup was about 40% compared to tablet as judged from changes in blood level with subjects not deficient in ascorbic acid intake.

Ascorbic acid and moisture contents were higher in vegetables produced during rainy season than in the same

vegetables produced during the dry season by irrigation. The difference was significant ($P < 0.05$) in red peppers and okro.

The native method of boiling vegetables in water resulted in ascorbic acid loss ranging from 38.9 to 78.2 per cent. Ascorbic acid loss due to cooking of the vegetables into soup ranged from 66.2 in "kuka" to 94.6 per cent in stew. Storage and reheating of the soups decreased the ascorbic acid content. At 24 hours post cooking, "kuka", okro and "kalkashi" had 5.2mg, 7.8mg and 9.1mg ascorbic acid per 100g consumable soup. By 48 hours none of the soups examined had any appreciable amount of ascorbic acid left.

Sun-drying and storage at room temperature of vegetables up to a period of six months reduced their moisture and ascorbic acid contents. Sun-drying alone produced between 92.9 to 98.5 per cent loss in moisture content and 21.3 to 58.0 per cent loss in ascorbic acid. Storage of dried products caused about 21.0% loss within the first month of storage and 66% after six months. Maximum ascorbic acid retention of 58.4% was observed in stored dehydrated "zogale" while minimum retention of 35.4% was observed in "kalkashi". Ascorbic acid loss in stored dehydrated vegetables was significantly ($P < 0.05$) affected by duration of storage.

During a survey of some medical centres in the Northern States of Nigeria for the incidence of clinical scurvy, no clinician or other medical personnel reported ever diagnosing classical cases of scurvy. However, 2.41% reported that gingivitis was a common disorder in children during the dry season and responded very well to both ascorbic acid and penicillin therapy. Also 89.2% of the medical personnel reported prescribing ascorbic acid to patients with common cold.

The adequate intake of ascorbic acid of the population studied seems to correlate well with the probable absence of clinical scurvy. There is however, a need for expanded dry season vegetable farming in order to decrease reliance on dried stored vegetables.