OLABISI ONABANJO UNIVERSITY
AGO-IWOYE NIGERIA

EIGHTEENTH INAUGURAL LECTURE

"FIBRE AND FIBRE-LIKE SUBSTANCES" IN HEALTH DISEASE

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ACKNOWLEDGEMENT

Mr. Vice Chancellor sir, I like to give thanks to God Almighty for making today possible. This day is special to me being mine 53rd Birthday. God has made it possible for me to deliver the 18th Inaugural Lecture today. It's a day of double blessing. The Lord has accomplished several things in my life, the only way to acknowledge him is to say publicly "Thank you father". I am indeed appreciative of your support.

Appreciation to Colleagues

I want to thank particularly all the members of the Faculty of Basic Medical Sciences, the members of the Departments of Biochemistry, the Provost and members of the Obafemi Awolowo College of Health Sciences, Colleagues in all Faculties, Colleges; Administrative and other units of the University, the Governing Council for their love, goodwill and interest in my person, work and comradeship. It has been a rewarding period so far. To my students in the Medical school, and the biochemistry department, I say thank you for the challenges and thought provoking time that we have spent together over the years. Great Osuites! Greater Osuites!! Greatest Osuites!!!. You still remain great in my opinion. Greater things are bound to happen to this institution - (Amen).

Appreciation to Family Members

I owe a lot to several individuals who have influenced my life positively over the years. To my Late Father Pa Ezekiel Taiku Osilesi, Alias "Ajulo-opin" – who gave all to encourage his children and others to be the best they could be in all endeavors; to Late Mrs. Christiana O. Osilesi, my beloved mother, I cannot but truly cherish the memories that you left behind. May their souls rest in perfect peace – Amen.

To my sister and her husband Olori S. A. Erinle and HRH Kabiyesi Oba S. O. Erinle, the Ayanta of Odoyanta, Ijebu; your encouragement and support would remain indelible in my mind. You have truly done well in my life. To my Uncle and his wife, Mr. and Mrs M. O. Ogunkoya the former Sole-Administrator for Labor in the Babaginda Era, you are much loved and cherished for the support you gave while attending the Federal School of Science, Lagos. To my brothers and Sisters, Mike, Kola, Ireti Popoola and the extended members of the family, you are all much appreciated and thanks for the support given while receiving the tertiary education at Howard University, Washington, D.C.

To an Uncle that started it all at the primary school level, whom I stayed with as a teacher's boy at Ogere, Ishara-Wesley Schools, Mr and Mrs S. O. Anibaba, your impact in my life remains vivid. You are much loved.

Thanks to members, Social Club's, Friend's Classmate and Students

Let me quickly acknowledge with gratitude my childhood friends and classmates at the Ago-Iwoye Secondary School, Ago-Iwoye. We have remained very close friend over the years. Members of Sagamu club here present I say "Orisagamu Agbe wao". Members of fountain of hope international, I say "fountain for Christ". Old students of CMS grammar school, federal school of science you are all welcomed.

I want to express my gratitude to my research mentors: Prof James Adkins, Prof Enid Knight of Howard University; Prof David L. Trout of the Beltsville Human Nutrition Center, Beltsville, Maryland; Prof David J. A. Jenkins of the University of Toronto; Toronto, Canada for support, opportunities given to improve the knowledge and expertise in Nutrition research. I must thank my friends, former Deans of the Faculty of basic medical sciences Prof F. O. Osiyemi and Prof. J. O. Olowookere, for encouragement and support given along the way. I have worked with many young scientist; Dr. O. Adebawo, Dr. Adenuga the HOD-Biochemistry and all the colleagues in the Department. Thanks indeed, Mr. Afolabi Ogunledun a true friend and supporter. I shall always appreciate the brotherly love. Also, I wish to thank my students, both undergraduate and postgraduate, for the constant inspiration and joy that they have given me.

Appreciation to the Akarigbo of Remo, Ewusi of Makun, Negbuwa of Ibido, Sagamu, Sagamu Economic Council, Methodist family.

Mr. Vice Chancellor Sir, permit me to thank publicly here the Akarigbo of Remoland HRH. Oba Michael Adeniyi Sonariwo for his fatherly support. I want to also thank the Ewusi of Makun, Sagamu Oba Ogunsowo, Inonuwa II for extending the offer of Chieftaincy to me and my wife about two years ago; I could remember that we accepted the offer in good faith and informed him that we shall honor it at an appropriate time. But coincidently, I am told that an offspring of an Oba does not take-up a chieftaincy title. I was pleasantly surprised when without any fan-fare or prior knowledge, the Negbuwa of Ibido, Sagamu - HRH Oba Taoheed Adebayo Obayoruba II honoured me and my wife with the titles of "Otunba Bobadega and Yeye Bobadega of Ibido, sagamu of May, 2000. "Kabiyesi, Kade pe lori, ki bata pe lese, ki irukere ko di abere" We hope to celebrate the Iwuye ceremony on the 20th of January in Sagamu. The son of

the soil, trained in America has come home to stay. We thank God for his infinite blessing and mercy.

Members of the Sagamu Economic Council, I thank you for the call to service, by appointing me as Vice President at the last AGM; I promise to do my utmost in promoting the interest of Sagamu and Remo in the scheme of things in Ogun State and Country as a whole. To the fathers and brothers in Christ, I thank the Bishops, Reverends and other members of the Remo Methodist Diocese, hereby present, as a Senior Circuit Steward to the Agbowa Methodist Circuit, I shall do my utmost by the grace of God to propagate the gospel and do that which will bring glory and honour to the Lord – Amen.

I wish to extend my thanks and congratulate sir, Mr. Vice Chancellor, Prof Layi Ogunkoya for bridging the gap for this institution. You came in under great tumult; God has crowned your efforts, by restoring peace and normalcy to this great institution. May I recall Lord Tennyson's work. "I am a part of all that I have met". Your term as helmsman though short, but posterity will no doubt judge your contributions. You will no doubt be registered to fame and great acclaim, for all you have done for Ogun state University.

Tributes to my wife, children and In-laws

Finally, most of all the tribute is due to my darling wife Chief (Mrs) Elizabeth Olugbemiga Osilesi (Nee Awoseyi); the Yeye Bobadega of Ibido, Sagamu for her care and support during all these years of painstaking marriage to research and the laboratory. She is loving, kind, understanding and caring. She is a source of encouragement to me at all times. A born Christian to late Baba Ijo of Ife Methodist Church, Sabo, Ile-Ife; late Pa J. A. Awoseyi; and the current Iya Ijo of Otapete Methodist Cathedral, Ilesha – Lady Victoria Wende Awoseyi – Knight of John Wesley. I thank her for her understanding, endurance and care. In proverbs 3: 1- 10, it is written "A wife of noble character who can find her. She is worth more than rubles".

Mr. Vice Chancellor sir, I must thank my children: Oluyemisi, Olusola, Ayodele and Omotunde. They are not able to be present because they are all pursuing their academic and other interests in the United States of America. May God continue to be with them – Amen.

Finally, I must recognize the presence of my in-laws Mrs M. O. Obembe, Retired Permanent Secretary, Osun State Ministry of Establishment; Dr. Awoseyi, Mr I.O Ajijola, former Registrar, University of Lagos and Lawyer Ajijola – and many others. I do recognize you all and wish you traveling mercies.

Recognition of Corporate Bodies

Present here today are Directors and Chief Executive Officers, Group Senior Managers of Lever Brothers Nigeria Plc, Nestle Nig. Plc, West African Milk Company and others corporate bodies here present. I must personally thank you all for your cooperation over the years in promoting Nutrition education amongst our people and the support for our Journal efforts.

Those of you who have granted us food hospitalities, may your shadows never grow less.

I thank God for your presence and attention, and May the Almighty God bless you all – Amen.

Mr. Vice Chancellor Sir,
The Members of Council herein present
The Registrar and Secretary to Council
Provost of Obafemi Awolowo College of Health Sciences
Other Provosts and Deans of Faculties
Principal Officers of the University
Our Colleagues from other institutions
His Royal Highnesses here present
My Lord Spiritual and Temporal
Invited Guests and Friends
Distinguished Ladies and Gentlemen
Great Osuites! Greater Osuites!!
Greatest Osuites!!!

This is my Story. This is my Song.

Thank you.

PROF. ODUTOLA OSILESI
18th January, 2001

(A) INTRODUCTION

Mr. Vice-Chancellor and Chairman of this occasion, Professor Layi Ogunkoya, Registrar and other Principal Officers of the University, Provosts and Deans of Colleges and Faculties, Fellow Professors, Our Royal Highnesses here present, My Lord Spiritual and Temporal, friends from sister Universities, friends of Ogun State University, staff and students of this young and promising institution, distinguished ladies and gentlemen, gentle men of the press.

I must first of all thank Almighty God for making this day possible and express my profound gratitude to the Vice-Chancellor for giving me the opportunity to deliver this inaugural lecture and pay this important due to Ogun State University, where I was promoted to a Professor's position since 7th July 1997.

Mr. Vice-Chancellor, Sir, the aim of an Inaugural lecture is to allow the appointed Professor the opportunity to give an account of his/her scholarship in terms of research activities, elucidate the contributions to knowledge and the possible benefits the society and the World-at-large may gain from the several years of sleepless nights. This Inaugural lecture would attempt to explain:

(i) My contributions to medical knowledge and Health of mankind through our research investigation on "Fibre and Fibre-like substances in health and disease globally;

(ii) Promotion of nutrition and health care information by fostering nutrition policy and food standard for Nigerians;

(iii) Initiation and promotion of avenues for co-operation between professional associations and industries, leading to endorsement/certification and legislation on food issues at the national level.

It would probably be necessary to look back the memory lane of my academic stewardship so as to justify this presentation. From a simple beginning at: Ago-Iwoye Secondary School (1960 -1965), to Hussey College, Warri (1966 – 1967), C.M.S Grammar School, Bariga, Lagos (1967 – 1968) and Federal School of Science, Onikan, Lagos (1968 – 1969); the foundation of my scientific interests was established. With the encouragement of my Late father and mother, Pa Ezekiel Taiku and Christiana Oyebowale Osilesi, I was admitted into Langston University, Langston; Oklahoma (1970), USA and transferred to Howard University, Washington. D.C (1971 – 1973), where I obtained a B.Sc. degree in Chemistry (Cum Laude). At Howard University; I was invited as a graduate Teaching assistant to do a PhD work in Human Nutrition and food by Professors James Adkins and Enid Knight in 1975. In the course of performing my duties

as graduate student's seminar coordinator within the school of Human Ecology at Howard University,

I met Prof. David L. Trout, a Carbohydrate Nutritionists, animal Physiologist and United States Department of Agriculture (USDA) Scientist with the world-renowned Beltsville Human Nutrition Center, Beltsville, Maryland. He singularly introduced me to the world of dietary fibre and their possible uses in Health and Disease. He is my scientific mentor, who encouraged me to do the preliminary works on the edible gums, their effect on hepatic lipogenesis and gastric emptying of nutrients. We have remained good family friends over the years.

(B) DIETARY FIBRE HYPOTHESIS: HISTORICAL PERSPECTIVE

The term "dietary fibre" was coined in 1953 by Hipsley to describe plant cell wall components of food that was observed to be protective against the condition of pre-eclampsia of pregnancy and its associated raised blood pressure. Dietary Fibre (DF) has played an important and healthful role in the history of human food supply. First recognized as producing laxative effect in whole wheat bread versus that of refined wheat flour (Hypocrites).

In the 19th century, Graham, of the Graham Cracker fame observed the "unhealthful" effects of refined carbohydrates; whilst Kellogg® and Post® encouraged an increase in wheat bran consumption. The modern era of fiber research commenced in the middle of the 20th century with the development of the "dietary fibre hypothesis" which were based on observations in Africa of distinct differences in incidence of certain chronic diseases between blacks, who consumed diets rich in dietary fibre and whites with low fibre diets. Individuals with low fibre diets were prone to higher incidence of coronary heart disease, diabetes mellitus, obesity, diverticular disease and colorectal cancer, which were common in Western Societies.

Comparison of 'Western' and 'Third World' Diseases

Condition	*United States (? High-Risk Diet)*	*Africa (? Low-Risk Diet)*
Ischemic heart disease	Responsible for one third of all deaths	Virtually unknown; incidence beginning to increase slowly in large cities.
Appendicitis	Most frequent of abdominal	Virtually unknown in rural areas; incidence beginning to increase in more westernized communities.
Diverticular disease	Most common disease of colon.	Almost unknown
Gallstones	Present in some 10% of adult population	Exceedingly rare
Varicose veins	Present in over 10% of adult population	Present in propbably under 0.1% of those living in traditional manner; increasing with adoption of Western customs.
Deep vein thrombosis and resultant pulmonary embolism	Hospital patients at high risk.	Very rare
Hiatus hernia	Demonstrable in nearly half of population over 50 years old.	Almost unknown
Hemorrhoids	Demonstrable in nearly half of population over 50 years old.	Rare or very rare, according to degree of Westernization
Cancer of colon and rectum	Second only to lung cancer as cause of death from neoplasms.	Rare
Obesity	Nearly half of adult population markedly overweight	Rare among those living wholly on traditional diets; increasingly common with urbanization and adoption of Western foods.

Adapted from D. P. Burkitt, A. R. P. Walker, N. S. Painter: Dietary fibre and disease. JAMA 229:1068, 1974

TABLE 1: COMPARISON OF "WESTERN" AND WESTERN DISEASES

(C) DEFINITIONS OF DIETARY FIBRE

Opinions are divided about how dietary fibres should be defined. One definition relies on 'Structural' view that takes into account the origins of dietary fibre in plant cell walls as 'non-starch polysaccharides'. A second definition is based on the Physiological and nutritional consequences of consuming dietary fibre; focusing on the fundamental 'unavailability of dietary fibre for absorption and relegating the plant cell wall origins to secondary importance. In this view, dietary fibre is 'polysaccharides and lignin that are undigested by the enzymes of the small intestine. The dietary fibre polysaccharides are associated together in the complex structure of plant cell wall, where they exist in raw or unrefined foods. The Dietary fibre polysaccharides are consumed as cell wall fragments or even as whole cell walls. 'Pure' polysaccharides are eaten only when isolated or added to foods as thickening or water-holding agents or as fibre enrichment components. The Dietary polysaccharides components consist of insoluble (cellulose, hemicelluloses) and soluble (Pectin, glucans, gums, mucilages, seed gums and bacterial polysaccharides

TABLE 2: POLYSACCHARIDES OF CELL WALL AND FOOD SOURCES

General category	Structural Classification	Food Sources
INSOLUBLE		
Cellulose	B-D-Glucan (4-linked)	Fruit Vegetables and Cereals e.g. oat bran.
Hemicelluloses	Xylans (including arabinoxylans and 4-0-methyl glucuronoxylans) B-D-Glucans (3-and 4 linked Xyloglucans	Cereal grains e.g rye, oat bran
SOLUBLE		
Pectic Substances	Galacturonans, rhamno-galacturonans, Arabinans Galactans, Arabinogalactans	Fruits, berries, jams and jellies
Beta-glucans	(1 3) (1 4) beta-D-glucans	Oat bran, barley seeds
Plant Exudate gums	Unionized sugars and Uronic acid units	Gum Arabic, Tragacanth, karaya
Mucilages	Linear copolymers of D-mannuronic acid and L-guluronic acid - contains sulfate esters	Agar, Carrageenan, furcellaran and alginates found in seaweed extracts
Legume seed gums	Galactomannans	Okra, legume seeds
Bacterial	Cellulose man chain, glucose, mannose and glucuronic acid side chains.	Produced by microbial fermentation

Most polysaccharides are found to be abundant in several food sources such as fruits, vegetables, grain and cereal product, legume seeds etc.

Finally, Dietary fibre may be defined as plant material that resists digestion by human alimentary enzymes. It includes substances of unique chemical structure.

D. DIETARY FIBRE COMPONENTS

Dietary fibre components consist mainly of polysaccharide, i.e. complex polymers of sugar units: which belong to the class of compound called carbohydrates. The sugar units are linked together in long chains to form polymers which may differ:

BOX 1

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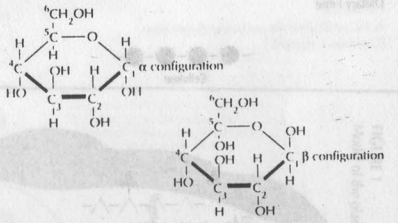
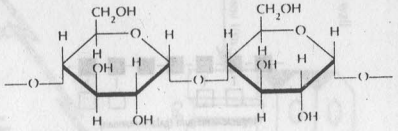
BOX 1
Sugar components of dietary fibre polysaccharides

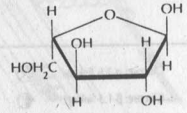
Polysaccharides are large molecules (polymers) in which simple sugars (monosaccharides) are linked together in long chains. The most commonly occurring monosaccharides contain either five or six carbon atoms built into a ring structure. Thus glucose, one of the commonest sugars containing 6 carbon atoms, has the chemical structure:



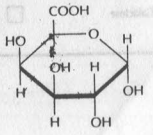
Imagine a ring as occupying a horizontal plane. The thick lines indicate parts of the molecule projecting forward, the thinner lines, those pointing back. Two different stereo chemical forms exist, depending on whether the hydrogen atom at carbon 1 is pointing above or below the plane of the ring. In a polymer, chemical links are formed between carbon atoms in any position of one sugar ring and any position of the next, for example α-1,4 (as found in starch); β-1,4 (as found in cellulose).



A typical 5-carbon sugar found in fibre is arabinose:

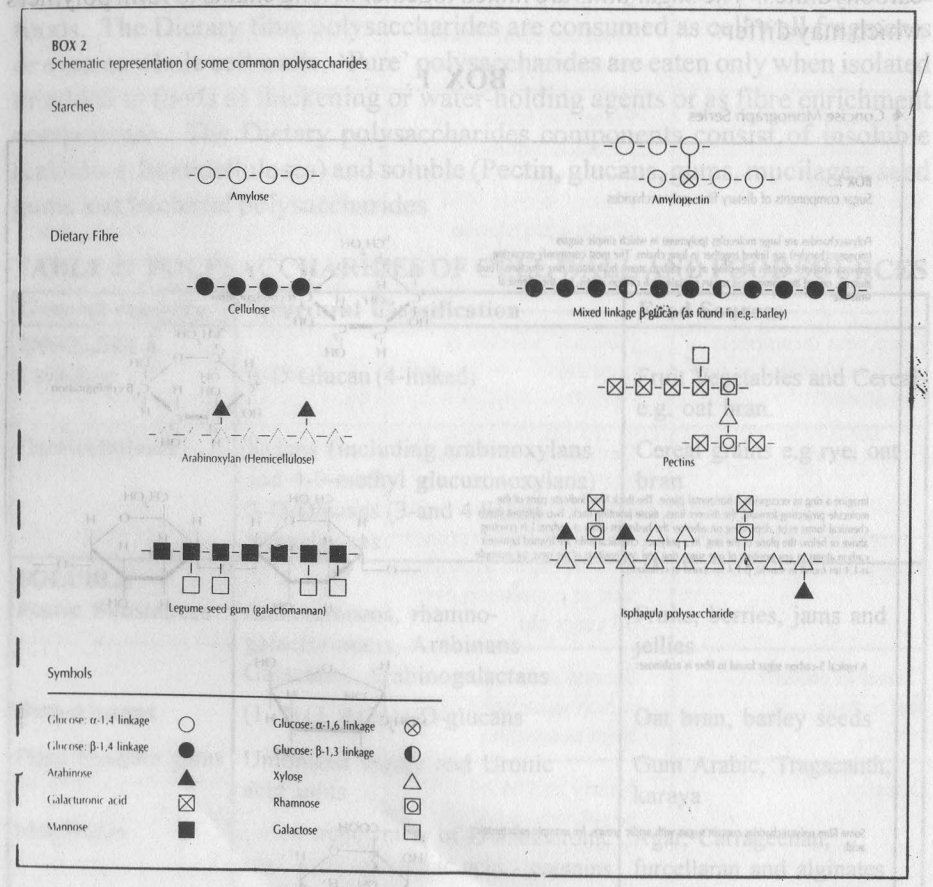


Some fibre polysaccharides contain sugars with acidic groups, for example galacturonic acid:



√ According to the number of monosaccharides linked together.
√ The different types of monosaccharides present
√ Their order in the polymer chain.
√ The presence of branches from polymer backbone
√ The types of linkage between one monosaccharide unit and the next.

BOX 2



The polysaccharides may be categorized on the basis of solvent extraction as insoluble polysaccharides (cellulose, Hemicelluloses) and soluble Polysaccharides (Pectins, Beta-glucans, plant exudates gums, mucilages, Legume seed gums, Seed weed polysaccharides, Bacterial polysaccharides, Lignin.

Recently, the AOAC International Workshop on Definition and Analysis of Complex Carbohydrates/Dietary fibre in November 1995 agreed that dietary fiber and complex carbohydrates should be defined as starches plus non-starch polysaccharides, whilst complex carbohydrates be defined as available starch plus dietary fibre (non-starch polysaccharide plus lignin).

Dietary fibre may then include not only:

- Non-starch polysaccharide, plus
- Resistant oligosaccharides
- Lignin, but additionally
- Resistant starch.

FIG. 1

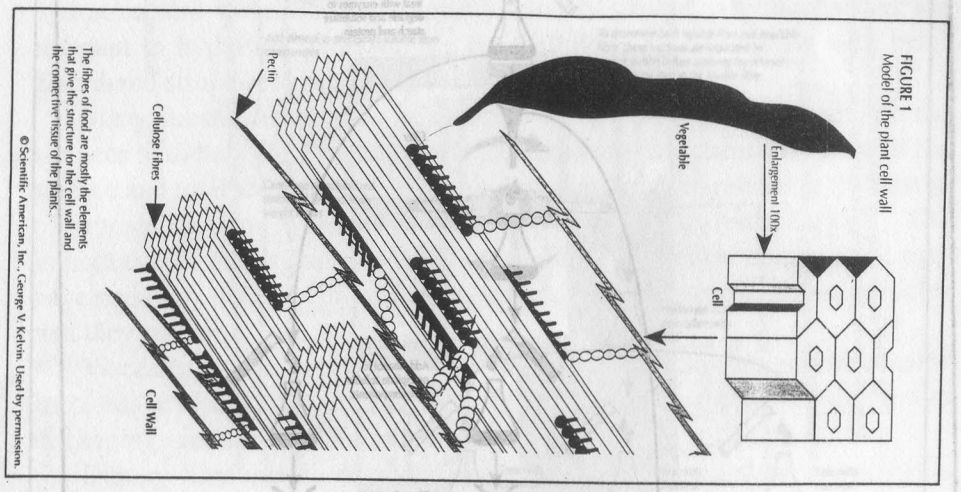


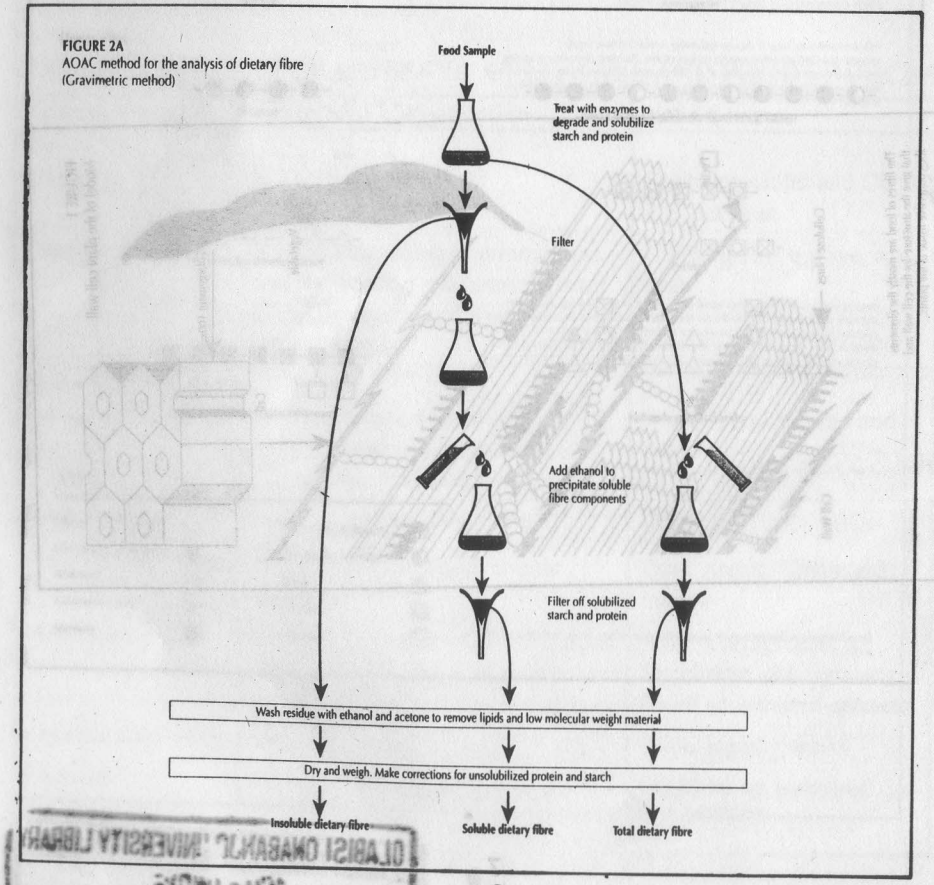
FIGURE 1
Model of the plant cell wall

E. ANALYSIS OF COMPONENTS OF DIETARY FIBRE

Two types of methods are currently being used:

(i) **The Gravimetric methods** – the most acceptable is the Association of Official Analytical Chemistry (AOAC) method. This method employs the use of enzymes to digest away non-fibre components, plus a correction for protein and minerals in the residue. Fibre is thus separated from non-fibre components and weighed. The first Gravimetric method weighed the insoluble residue (crude fibre) after boiling with dilute acid and alkali. Then followed by extraction with detergents. Acid detergents separate out a residue of cellulose plus lignin. A neutral detergent method measured cellulose, hemicelluloses and lignin, whilst pectin and other soluble components were not measured. Finally, use of enzymes to digest away the non-fibre components result in precipitating the soluble fibre components with alcohol, so that none of the fibre fractions escapes analysis.

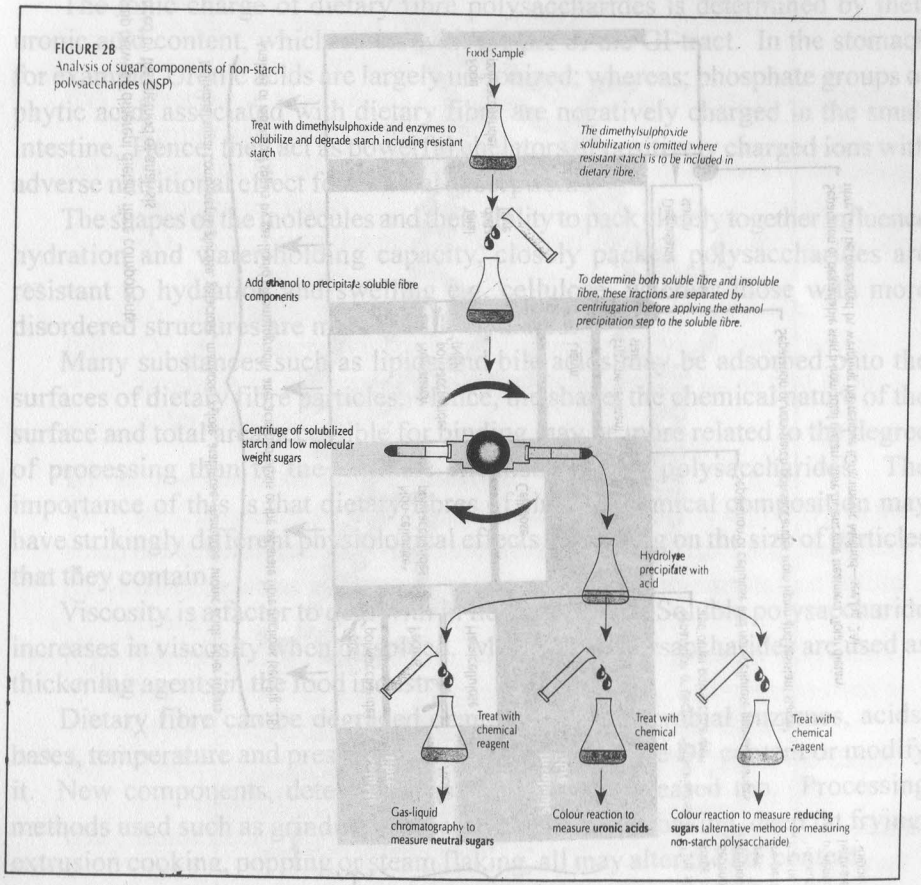
FIG. 2A



Gravimetric method requires less sophisticated method and may suffice only to assess fibre for regulatory uses and not for information on nature and physiological properties of dietary fibre.

(ii) **Southgate Method** – involves the use of solvent and enzymes for separation of fibre from starch and low molecular weight sugars in food. It uses either the automated gas-liquid or high performance liquid chromatography for separating sugars after hydrolysis of the fractionated fiber fraction.

FIG. 2B



All methods rely on extraction procedures to separate individual fibre components on the basis of their physical properties; which defines whether a particular component, is either 'soluble', 'insoluble', 'cellulosic' or 'non-cellulosic' fractions. Figure 3 summarizes the range of fibre components that can currently be measured as influenced by several methods of analysis, which are diversified and vary in procedure. Total dietary fibre is calculated, as the residue weight corrected for residual protein and ash, and DF polysaccharides are the sum of neutral sugars and uronic acids.

FIG. 3

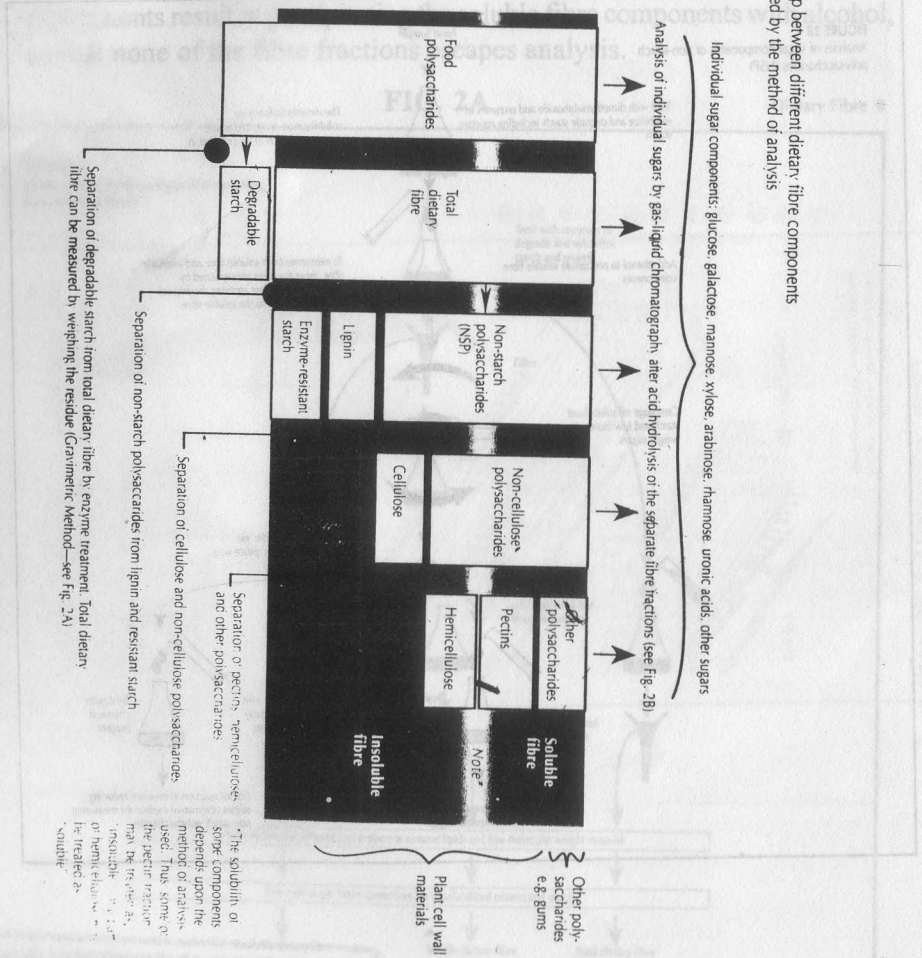


FIGURE 3
Relationship between different dietary fibre components as influenced by the method of analysis

E. PHYSICO-CHEMICAL PROPERTIES OF FIBRE COMPONENTS

The physical properties of the fibre components in foods are important determinants of their physiological effects. Polymer chains in fibre are held together by true chemical bonds: covalent linkages and non-covalent bonds. From the point of view of both food structure and physiologic function, the most important physicochemical properties are:

- Ionic charge
- Degree of hydration or water holding capacity
- Adsorption capacity
- Viscosity

The ionic charge of dietary fibre polysaccharides is determined by their uronic acid content, which varies with the pH of the GI-tract. In the stomach for example, Uronic acids are largely un-ionized; whereas; phosphate groups of phytic acid, associated with dietary fibre are negatively charged in the small intestine. Hence, they act as powerful chelators of positively charged ions with adverse nutritional effect for mineral absorption.

The shapes of the molecules and their ability to pack closely together influence hydration and water-holding capacity, closely packed polysaccharides are resistant to hydration and swelling e.g. cellulose, whereas those with more disordered structures are more readily hydrated.

Many substances such as lipids and bile acids may be adsorbed onto the surfaces of dietary fibre particles. Hence, the shape, the chemical nature of the surface and total area accessible for binding may be more related to the degree of processing than to the intrinsic chemistry of the polysaccharides. The importance of this is that dietary fibres of similar chemical composition may have strikingly different physiological effects depending on the size of particles that they contain.

Viscosity is a factor to deal with in liquid systems. Soluble polysaccharide increases in viscosity when dissolved. Many fibre polysaccharides are used as thickening agents in the food industry.

Dietary fibre can be degraded or modified by microbial enzymes, acids, bases, temperature and pressure. They either reduce the DF content or modify it. New components, determined as DF, can be increased too. Processing methods used such as grinding, fermentation, cooking, baking, deep fat frying, extrusion cooking, popping or steam flaking, all may alter the DF content.

FIG. 4

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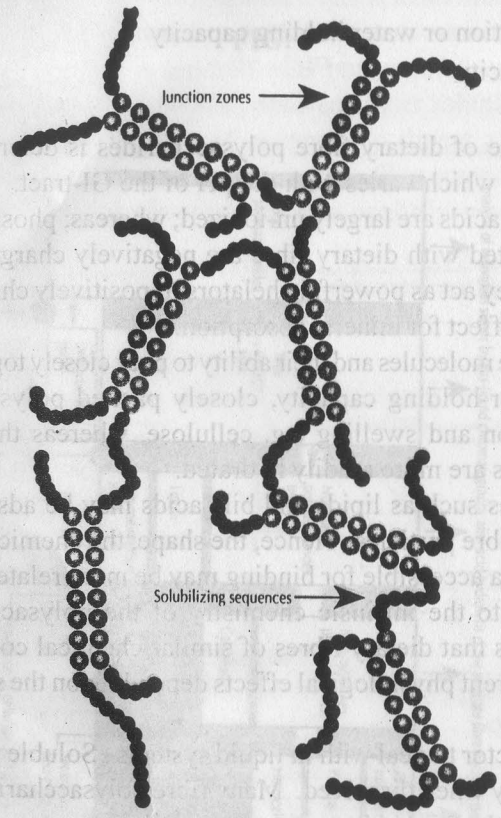
FIGURE 4
Structures within a hydrated polysaccharide network



Fibre polysaccharides can exist in either ordered or disordered forms, which have quite different geometries. Common motifs include assemblies of flat ribbons (cellulose fibrils), double helices (starch) and buckled chains with cavities occupied by bound ions. Three-dimensional networks of fibre molecules in fruit, vegetables and manufactured food products include both ordered and disordered regions. The former consist of junctions between parts of adjacent polysaccharide chains ("junction zones" in the figure). Too much order, however, would result in a packed solid. A three-dimensional network that can hold water also requires some disordered regions to interrupt the packing and stretch between the junctions ("solubilizing sequences" in the figure).

G. PHYSIOLOGICAL EFFECTS RELATED TO HEALTH AND DISEASE

Mr. Vice-Chancellor sir, whilst noting that dietary fibres, by definition, are not digested in the small intestine, its physiological effects are, however, manifested at the level of the GI-tract.

1. DF at Stomach and Small Intestine

It is the physical properties of DF that play a major role:

(i) DF may influence the degree of Viscosity of stomach contents.

(ii) Rate of food component emptying from stomach into small intestine is affected.

(iii) Degree of Viscosity simultaneously may affect mixing of viscous polysaccharides and contact with intestinal enzymes that digest carbohydrates, proteins and fats.

(iv) Increase in viscosity as a result of DF, can shift sites of absorption further along the GI-tract.

(v) Presence of DF causes adaptive changes in absorptive cells lining the intestine thus:

(a) Decreasing the number of absorbing cells higher up the GI-tract and

(b) Increasing the number of absorbing cells lower down.

(vi) DF in increasing Viscosity may alter the sites and rate at which products of absorption – simple sugars, amino acids and lipids – enter the blood stream.

2. DF at the Level of Large Intestine

Mr. Vice Chancellor sir, as a consequence of inability to digest DF in the small intestine, fibre components are carried into the large intestine, where

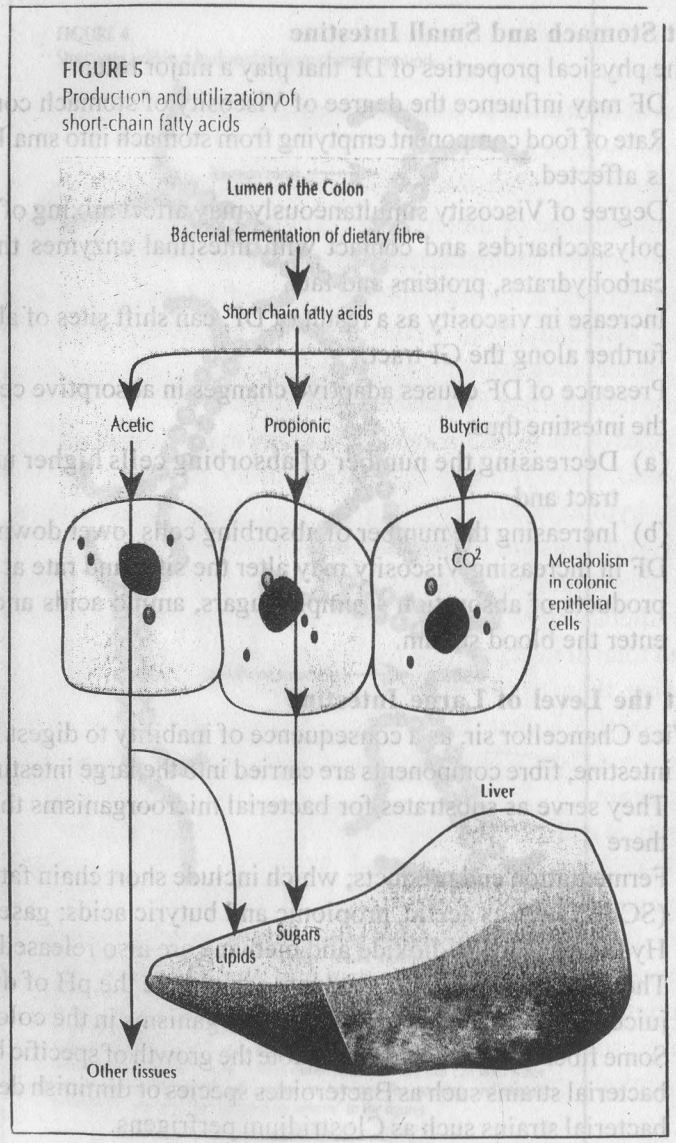
(i) They serve as substrates for bacterial microorganisms that reside there

(ii) Fermentation end products; which include short chain fatty acids (SCFA) such as acetic, propionic and butyric acids; gases such as Hydrogen, carbon dioxide and methane are also released.

(iii) These fermentation end products can reduce the pH of duodenal juices and alter the balance of microorganisms in the colon.

(iv) Some fiber types are able to promote the growth of specific beneficial bacterial strains such as Bacteroides species or diminish detrimental bacterial strains such as Clostridium perfrigens.

Fig. 5



(v) SCFA end products e.g. Butyric acid appears mainly to be used as fuel for cells lining the colon, while propionic and acetic acids are absorbed into the blood and utilized by liver and other tissues for synthesis of lipids and sugars respectively or utilized directly as metabolic fuel.

(vi) The gases produced may be expired through the lungs or may cause flatulence or intestinal pain.

Mr. Vice Chancellor Sir, we must note that the fermentation products of colonic degradation appear to alter large intestinal physiology and metabolism. The extent of fermentation, the range and the nature of end products depend largely on the types of fibre consumed.

Hence, above has allowed us to combine both the physical properties of water solubility and insolubility of polysaccharides with fermentability or non-fermentable properties to classify fiber types into:

(a) Soluble (Viscous, easily fermentable) dietary fiber. (SDF)
(b) Insoluble (non-viscous, slowly fermentable) dietary fiber. (IDF)

These general types of fiber may exhibit different physiological effects, which influence the prevention and management of disease and metabolic states.

The Soluble Dietary Fibers (SDF): include components such as:

(a) Soluble **b**-glucans (b) pectin (c) gums
(d) mucilage (e) Some hemicelluloses.

All can modulate the following physiological and biochemical responses:

(i) Delay in transit time in the gut;
(ii) Delay gastric emptying
(iii) Impede the absorption of certain nutrients like glucose
(iv) Decrease serum cholesterol levels.

Insoluble dietary fibre (IDF): included components such as:

(a) cellulose, (b) lignin and
(c) Other hemicelluloses they modulate:
  (i) Increase intestinal transit time and fecal weight,
  (ii) Slow starch hydrolysis, and
  (iii) Delay glucose absorption.

TABLE 3

THE ROLE OF DIETARY FIBER IN THE PREVENTION AND MANAGEMENT OF DISEASE STATES AND METABOLIC CONDITIONS

Physicochemical property	Type of fiber	Physiological effect	Clinical significance
Viscosity	Gums, mucilages, pectins	↓ Gastric emptying ↓ Rate of small Intestine absorption	Diabetes Hypercholesterol
Particle size and water-holding capacity	Wheat bran, pentosan content, polysaccharidelignan mixtures	↑ Gastric emptying ↓ G.I. tract transit time ↓ Colonic intralumi nal pressure ↑ Fecal bulk	Constipation Peptic ulcer Diverticular disease Dilute potential carcinogens
Adsorption and non-specific effects Cation exchange	Lignin, pectin-mixed fibers Acidic polysacchari-des (i.e, pectins)	↑ Fecal steroid output ↑Fecal fat and nitro-gen loss ↑ Small intestine losses of minerals, trace elements, heavy metals	Hypercholesterol Negative mineral balance Antitoxic effect
Antioxidant Degradability (colonic bacteria)	Lignin (reducing Phenolic groups) Polysaccharides (free of lignan)	↓Free radicals in Digestive tract ↑ Production of gas and volatile fatty acids ↓Cecal pH	Anticarcinogenesis Flatus Energy production Serum cholesterol Carbohydrate/lipid metabolism

The SDF are highly fermentable, whereas the IDF are slowly – fermentable. SDF affect lipid metabolism, where the IDF contribute more to faecal bulk and reduced transit times. Clearly, the physico-chemical properties of fibre such as particle size, water-holding capacity, viscosity, cation- exchange and binding capabilities listed in Table 3, are specific for every fiber source, however, these properties are modified with cooking or digestion. They can modulate the diseased states and metabolic conditions. Infact, fibre has been implicated as important in:

(i) Various aspects of bowel function and disorders
(ii) Influencing several metabolic diseases (diabetes hypercholesterolemia)
(iii) Control and/or prevention of a variety of carcinomas (cancer)
(iv) Control and/or prevention of diseases affecting the cardiovascular system. (Ischemic heart disease, coronary heart disease, thrombosis etc).

3. FIBRE AND DIGESTIVE DISORDERS

Lack of "fibre" in the diet have been associated with several diverse disorders of the GI-tracts; such as constipation, hemorrhoids, hiatus hernia, duodenal ulcer, gall stones, Crohn's disease or appendicitis.

It is true that low dietary fibre intake may play a part in the development of some digestive disorders, however, the extent to which increasing fiber intake may provide benefits may depend upon:

(i) The natural history of the disorder
(ii) The type of fibre being consumed
(iii) The form of fibre in its food form
(iv) Personal circumstances of the individual

However, there is sufficient scientific basis for association between consuming too little dietary fibre and the condition of hiatus hernia, duodenal ulcer, gallstone, Crohn's disease. Reasonable evidences are available to associate low fibre intakes to irritable bowel syndrome, diverticulitis or colon cancer. Constipation can be regarded as a disorder of large intestinal motility that may respond to the mild laxative effect of dietary fibre, rather than the result of a fibre-deficient diet.

4. FIBRE AND ENERGY VALUE: ENERGY BALANCE AND OBESITY

Increase in intake of fibres normally leads to increase in the bulk of stools (bulky stools), which may decrease energy available to the body, by trapping energy yielding components into the stools, partly as components of bacterial

cells. The fermentation of fibre into SCFA, which can be absorbed from the large intestine, may make energy available to the body, but the extent of energy will depend on the composition of fibre components in the diet.

However, increasing DF consumption pattern can reduce feelings of hunger, increase feelings of satiety and thereby reduce food intake. Hence, high fiber diets are useful in preventing unwanted weight gain or reduce weight, due to their caloric contribution, DF contributes about 2kcal of energy per gram compared to starch, protein, 4kcal and fat, 9kcal.

5. INFLUENCE OF DF ON GLUCOSE CONTROL (DIABETES)

Increased intakes of dietary fibre are useful in treating conditions of mild elevation of blood glucose (hyperglycemia) to overt non-insulin dependent diabetes mellitus (NIDDM). Glucose control can be exacerbated by lack of DF and ameliorated by increased consumption of dietary fibre. When starchy foods are eaten, they release sugar into the blood circulation, its utilization by tissues is aided by secretion of insulin into the blood. When tissues become insensitive to the action of insulin, insulin resistance occurs. Thus more insulin is produced to aid glucose breakdown and resting blood concentrations of glucose and insulin rises. This condition is often associated with obesity, high blood triglyceride concentration and hypertension. The soluble types of DF e.g. pectin, gums, tend to:

(i) Reduce rate of entry of glucose into blood
(ii) Spread out rise in blood glucose.
(iii) Affect secretion of insulin over a longer period
(iv) Alter other hormonal effects.

Hence, foods that have above effect and high content of SDF are said to have a low 'glycemic index' and are useful in the treatment of NIDDM. We shall be hearing more about that shortly.

6. DF ON LIPID METABOLISM; CORONARY HEART DISEASE (CHD) CARDIOVASCULAR SYSTEMS

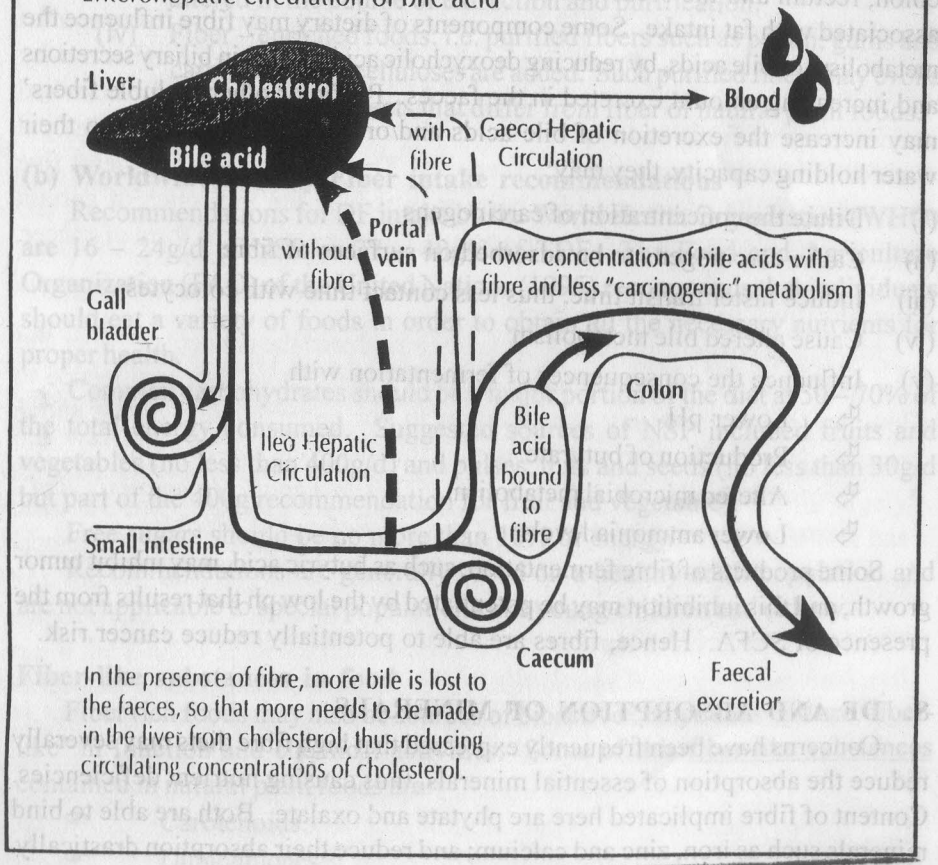
Fibres influence in managing body weight, high blood pressure, reducing the concentration of cholesterol in Low lipoprotein cholesterol fraction (LDL-Chol) has been demonstrated by several investigators. SDF, but not IDF play a major role. There seems to be little effect on triglycerides or on high-density lipoprotein cholesterol (HDL-Chol). Amounts needed in pure fiber forms are of the order of 10g – 12g per day; about 1kg of appropriate fruits or vegetables. The SDF cholesterol lowering effect has been observed with oat-bran amounts corresponding to 5 – 7g so soluble fibre per day (56 – 84g oat bran) content of

oat-bran thus:

(i) Bind to bile acids,
(ii) Reduce bile acid reabsorption and divert more cholesterol into bile acids
(iii) Cause an alteration in chylomicronemia and lymphatic transport of dietary fat.
(iv) Induce changes in hepatic production of lipoprotein or the peripheral clearance of lipoproteins.
(v) Produce SCFA that are capable of inhibiting cholesterol synthesis

FIG. 6

FIGURE 6
Enterohepatic circulation of bile acid



Ischemic Heart disease virtually unknown in Africa years ago, is increasingly surfacing in large cities, where high-risk diets (low in fibre) are now regularly consumed. Foods rich in soluble fibre components whilst capable of reducing blood cholesterol in those with a tendency to hypercholesterolemia, however, may not be effective in increasing fecal bulk. The type of fiber present in wheat bran is efficient in increasing fecal bulk but ineffective in regard to glucose tolerance and cholesterolaemia. It may however, offer protection against colorectal cancer.

7. DF "PROTECTIVE AGENT' AGAINST CANCER

Excessive amounts of bile acids in the large intestine are converted into substances that aid conversion of normal cells into cancer cells. High fat consumption has been implicated in high colo-rectal cancer. Cancers of the colon, rectum and the breast are the most likely of the common cancers to be associated with fat intake. Some components of dietary may fibre influence the metabolism of bile acids, by reducing deoxycholic acid content in biliary secretions and increasing amount excreted in the faeces. Pectin or other 'soluble fibers' may increase the excretion of bile acids and/or cholesterol and due to their water holding capacity, they may:

(i) Dilute the concentration of carcinogens
(ii) Cause carcinogens to be adsorbed on surfaces of fibre.
(iii) Induce faster transit time, thus less contact time with colocytes
(iv) Cause altered bile metabolism
(v) Influence the consequences of fermentation with
- Lower pH
- Production of butyrate
- Altered microbial metabolism
- Lower ammonia levels

Some products of fibre fermentation, such as butyric acid, may inhibit tumor growth, and this inhibition may be potentiated by the low ph that results from the presence of SCFA. Hence, fibres are able to potentially reduce cancer risk.

8. DF AND ABSORPTION OF MINERALS

Concerns have been frequently expressed that high fibre diets may severally reduce the absorption of essential minerals, thus causing nutrient deficiencies. Content of fibre implicated here are phytate and oxalate. Both are able to bind minerals such as iron, zinc and calcium; and reduce their absorption drastically.

Vegans are particularly prone to above nutritional deficiency due to no intake of meat and meat products.

H. FIBER IN THE DIET

The "dietary fiber hypothesis" rests on data from observation of populations eating a diet high in fiber. Most chemical and physiological studies, however, are conducted using single substances.

(a) Fiber in the diet can be obtained from four sources, namely:
(i) Whole food high in fiber
(ii) A high fiber fraction (such as wheat bran), which can be produced without affecting the structure or composition of the material as present in food.
(iii) Concentrated fiber such as cellulose or pectin, which has been, altered in the course of extraction and purification.
(iv) Fiber – enriched foods: i.e. purified fibers such as pectin, gums and carboxyl methylcelluloses are added. Such purified fibers may evoke physiological effects that differ from fiber of natural plant foods.

(b) Worldwide Dietary Fiber intake recommendations

Recommendations for DF intake by the World Health Organisation (WHO) are 16 – 24g/d of NSP or 27 – 40g/d of TDF. The Food and Agriculture Organization (FAO) of the United Nations (1995) recommends that individuals should eat a variety of foods in order to obtain all the necessary nutrients for proper health.

Complex carbohydrates should be a major portion of the diet at 50 – 70% of the total energy consumed. Suggested sources of NSP included fruits and vegetables (no less than 400g/d) and pulses, nuts and seeds (no less than 30g/d but part of the 400g recommendation for fruit and vegetable).

Free sugars should be no more than 10% of energy.

Recommendations are generally based on a healthy adult population and are not applicable to special populations like young children and elderly.

Fiber-like substances in food

Fiber rich foods may also be sources of bioactive compounds that are 'fiber-like' in function and chemical activities. Some of this fiber-like substances contained in natural plant foods are:

- Carotenoids
- Dithiolthiones

- Antioxidant Vitamins (C and E)
- Selenium
- Indoles and glucosinolates
- Flavonoids
- Coumarins
- Isothiocyanates and thiocynates
- Saponins
- Phenols (such as ferulic and ellagic acid)
- Sterols
- Inositol hexaphosphate
- Allium compounds

Most of the above antioxidant compounds have demonstrated clear biological activities. They have inhibited tumor growth to some extent, and some have hypolipidemic properties. Several are antioxidant with sparing effects against oxidative destruction. Protection against free radicals can be enhanced by ample intakes of dietary antioxidants, which are abundant with increased consumption of fruits and vegetables. Fruits and vegetables are the principal sources of both Vitamin C and Carotenoids. The consumption of at least five servings of fruits and vegetables daily may reduce the incidence of certain degenerative diseases such as cardiovascular diseases and some form of cancer.

Contributions to Fibre Research

Mr. Vice Chancellor Sir, having clearly introduced the concept of "fiber and fiber-like" substances in health and disease, I shall crave your indulgence to allow me to enumerate my contributions to our understanding of the above concepts. My contribution may be listed in the following sub-heading:

- *Characterization of Edible gums (SDF) in hepatic lipogenesis and gastric emptying of nutrients (Starved-Refed Rat Models)*
- *Use of Edible Gums in (Xanthan Gum) – in dietary management of diabetes mellitus in humans.*
- *Use of fructose sweeteners for diabetic and dieters in obese and lean zucker rats (Genetically obese rats).*
- *DF effect on blood profiles, hormonal and fecal steroid responses in Diabetic subjects.*
- *Analysis of Dietary fiber contents of Nigerian foods.*
- *Use of Traditional Nigerian, natural food fiber sources such as Ewedu, Okro and Apon (Ogbono or Dikanut) in the management of glucose*

and lipid disorders (i.e. diabetes mellitus, Hypercholesterolemia and mineral imbalance).

- *Use of semi - purified fiber supplement in the management of non-insulin dependent diabetes mellitus (NIDDM). Use of fiber-excel.*
- *Prediction of Glycemic index for starchy foods worldwide*
  - *(i) Glycemic response to selected fruits and vegetables in Nigerian diabetic;*
  - *(ii) Use of Low glycemic index foods for management of diabetes and lipid disorders (different varieties of Nigerian beans).*
- *Management of Hypertension with the use of Vitamin C supplements (1000 mg/d) in American and Nigerian subjects.*
- *Resistant Starch (RS) as components of DF in Ogi breakfast meals.*
  - *(i) Nutritional improvement of Ogi by genetic manipulation of the high lysine-producing mutants of Lactobacillus plantarium as starter inoculum.*
  - *(ii) Glycemic responses to Ogi in healthy subjects and use in the management of diabetes mellitus.*
- *Use of vegetarian diets in management of*
  - *(i) High blood pressure*
  - *(ii) Haemorheological risk factors for cardiovascular disease in African subjects.*
  - *(iii) Diabetes mellitus*

H. DF AT THE BELTSVILLE HUMAN NUTRITION CENTER, USDA, BELTSVILLE, MARYLAND, USA

It was indeed the "Grace" of the Lord that made me to come in contact with Prof. David L. Trout of the Carbohydrate Laboratory, Beltsville Human Nutrition Center, the largest and best known of such centers in the world, largely sponsored by the United States Department of Agriculture. A place that has given me not only my doctoral dissertation, but welcomed me as a visiting Professor, and has given me an olive branch to come into their laboratory anytime I am in the United States to do research, a research space and facilities would be available to me. It's indeed a close association and honour. When I entered the Center in 1980, consumers were demanding for "light"; reduced-energy, reduced fat foods, so as to achieve the nutritional goal of 30% of total energy from fat without changing food habits. The ingredients available to replace some or all of the fat in food were categorized into two groups: fat substitutes and fat mimetic. The fat substitutes resemble fats energy when eaten e.g. sucrose

polyesters; whereas, the fat mimetic are food ingredients based on starch; cellulose or protein polymers that have been modified physically, chemically or enzymatically to provide fat like properties in the water phases, but they provide less energy than fat. The fat mimetic (see table 5) are essentially good water-binding agents. Edible gums thus became the source of interest for research at the center. Thus I was introduced into the world of Edible gums, which are soluble dietary fibers of little known use.

I. CONTRIBUTIONS TO MEDICAL RESEARCH AND KNOWLEDGE

1. **Characterization and Physiological – Effect of soluble fiber (Edible gum).** Early in 1979, I demonstrated that edible gums e.g guar, xanthan gum (all soluble fibers) possess the abilities to acutely reduce serum glucose and insulin by altering metabolic responses at the level of the small intestine. Here the slowing effect of edible gums on gastric emptying of nutrients was identified to be physiologically important [Osilesi et al Nutr. Res 4: 259 – 269, 1984] in the rat model; shortly after, we developed a rapid bioassay system that allowed the detection of graded metabolic responses to various forms of soluble fiber: Xanthan, guar, Carrgaeenan, Karaya, Pectin, Ghatti, Acacia and provided strong evidence that the physical property of fibers especially viscosity determined its potency in depressing two hepatic lipogenic enzymes (glucose-6-phosphate dehydrogenase and NADP-linked malic enzyme) and total lipid contents. [Osilesi O. Trout DL and Knight E. J. Nutr. 118, 462 – 68, 1988].

2. **Progress in DF research at Alcorn State University, Lorman, Mississippi, USA.** On completing the Ph.D at Howard University, Washington, D.C in 1981, I was immediately offered a very rare opportunity to Head, the Nutrition Department at Alcorn State University, a land grant state institution, as an Assistant Professor, with the unique privilege of leading a USDA-SEA/Criss project on the "Effect of diet on disease pattern in South Western Mississippi (a project of $1 million spanning a period of 5 years).

   We demonstrated through demographic and food resources data in rural and urban areas of Southwestern, Mississippi, USA, that:

   (i) The greatest need in physical assistance for mankind was transportation, occupation, education and skills in that order.

   (ii) That hunger remained the most prevalent problem amongst the

lowest income and lowest educated people.

(iii) That nutrition education is important for good health [Proc. Biennial Res. Symp. 4; (1982)].

(iv) That a careful selection of appropriate food resources, rich in nutrient, is essential for the improvement of nutrient intakes and health status of normal individuals.

(v) That a comparison of dietary mineral intakes on the basis of race, sex and age seem to indicate better intake of all minerals in whites than blacks, in youths rather than in adults.

(vi) That fiber intake was low in Urban dwellers and this predisposed individuals to diseases of Western Civilization e.g. Diabetes, Hypertension, Coronary Heart disease etc.

(3) DF, Fructose and Diabetes Management

(i) Inclusion of soluble fiber (Xanthan gum 12g/d) in muffins or bread

Having established the low fibre intake in diets of South-Western Mississippians, we added soluble fiber in the form of Xanthan gum, a pure and biosynthetic gum, obtained from Xanthomonans campestris (12g/day) to diets of newly diagnosed NIDDM subjects and reported within 12 weeks of feeding, a reduced serum cholesterol and lowered fasting and fed level of blood glucose. Hormonal profiles such as insulin, gastro-inhibitory polypeptide (GIP), glucagons and vasoactive intestinal polypeptide (VIP) were moderately affected. [Osilesi et al, Am J. clin. Nutr. 42: 597 – 603, 1985]. We thus demonstrated that when fiber is added to diets of diabetics (either as bread or muffins) blood glucose and hormonal controls are appropriately regulated.

(ii) Use of fiber-excel (30g of fiber) in NIDDM

A semi-purified fiber supplement (Fiber-excel) containing mixtures of water-soluble and bulk-producing complex carbohydrates was added daily to self-selected diets of NIDDM and non-diabetic subjects for two week. Plasma glucose was depressed after one week in diabetic subjects while triglycerides were reduced after one and two weeks in non-diabetics. [Ogunwole, Trout and Osilesi: J. Nutr. Biochem. 3: 353 – 358, (1992)]. Here, we tested mechanistic models that predicted how various changes in DF may affect the rate and magnitude (perturbations) of changes in blood lipids, so as to predict the rating of metabolic potency of fibers on the basis of chemical and physical properties.

Mr. Vice Chancellor Sir, those two earlier studies were the beginning of my transition as animal research scientist to Human Nutrition Research Scientist, a challenge that most scientists do not readily overcome, due to problems with human compliance. We have over the years carried out several human investigations, whilst using animal experiments to test concepts that are new.

(iii) Fructose, a dietary Sweetener

We showed that fructose, a dietary sweetener in the diet, has potential advantages in various clinical states such as diabetes, obesity and reactive hyperglycemia. Feeding fructose in obese, lean; diabetic and non-diabetic zucker rats (a genetically obese rat model), did not produce high blood lipids and lactic acidosis in zucker rats. Fructose feeding did not improve glucose intolerance in diabetic animals; rather it produced hyperinsulinemia in non-diabetic, obese animals [Koh, Mueller, Osilesi and Reiser. J. Nutr. 115: 1274 – 1284, 1985].

Research Activities in Ogun State University

On arrival in Ogun State University in 1984, I started to investigate the usefulness of natural vegetable fibre in the management of disease.

(iv) Natural fiber in food; in management of Diabetes, Hyperlipidemia

Selected vegetable fibers, traditionally consumed in Africa and the World-over, such as Okra (Hibiscus esculentus) and Ewedu (Cochorus Olitorus); both known to be slimy, viscous and gel-forming were seen to be hypoglycemic and hypolipidemic in streptozotocin induced diabetic rats. [Osilesi O. McCarthy P. et al. Nig. J. Med. Sci. 2: 37 – 45, 1991; Biosci. Res. Comm (BRC) 4: 65 – 75, 1992 and BRC 5: 71 – 79, 1993] We have thus confirmed that okra, ewedu and other vegetable fibers should be encouraged for regular use by diabetics and individuals with blood lipid disorders [Osilesi et al, Nig J. Nutr. Sci 14: 15 – 19, (1993)] and possibly against known traditional taboos, be used by all normal individuals for prevention of several diseases of Western Civilization.

(v) DF Content of Nigerian food staples

We were the first to measure the Total dietary fiber (TDF) content of Nigerian food staples using the modified Prosky's method. Earlier reports of crude fiber, neutral detergent fiber methods, infact, under-estimated

the fibre content of our traditional foods. With the TDF method, we were able to show the soluble and insoluble fibre fraction of our food. Soluble fiber content as percentage of TDF for groups of food averaged 33.7% for cereal products, 30.4% for vegetables, 26.6% for dried beans and 34% for fruits. Insoluble-fiber fraction as a percentage of TDF was 75% for all food groups [Osilesi et al, Nig J. Nutr. Sci 12: 7 – 10, (1991)]. By establishing the TDF, soluble and insoluble fibre fractions of Nigerian food staples, we have prepared the way for the inclusion of African food staples in the world-wide food composition tables and improved their potential metabolic role for clinical research.

4. DF and Glycemic Index (GI)

Epidemiological data has confirmed that greater than 2 million Nigerians and over 100 million people worldwide are suffering from diabetes. The classification of foods according to their effects on blood glucose is useful due to differences in response, which they elicit. Glycemic index (GI) is an established, physiologically based method used to classify foods according to their blood glucose raising potential. It compares the level of glycemia after equal carbohydrate portion of foods and ranks them relative to a standard (usually glucose or white bread). The GI-concept has been subjected to extensive research confirming its reproducibility, application to mixed meals and hyperlipidemia.

Table 6 enumerates the Glycemic index of foods that make the largest contribution to carbohydrate intake. Contrary to popular belief, low GI-foods are not the same as foods based on high complex carbohydrate and fiber, nor are high GI food those based on simple sugars. Infact,

(i) Foods producing highest glycemic responses include starchy foods e.g. bread, breakfast cereal, potatoes, whether high or low in fiber; because starch is fully gelatinized and can be rapidly digested and absorbed.

(ii) Foods with the lowest GI values include pasta, relatively unprocessed cereal foods, baked beans, dairy products and many types of fruits and vegetables [Brand-Miller et al. Nutr. Today: 34: 64 – 72, 1999].

We have successfully classified traditional African food-staples on the basis of glycemic index and constructed dietary models of high and low GI diets.

(i) High GI-starchy foods may increase fasting insulin levels and insulin resistance by promoting:
   (a) Faster weight gain
   (b) Higher body fat level
   (c) Higher adipocyte volume

TABLE 6

THE GLYCEMIC INDEX (GI) OF FOODS THAT MAKE THE LARGEST CONTRIBUTION TO CARBOHYDRATE INTAKE

High GI (>70)	GI	Moderate GI (56-69)	GI	Low GI (<55)	GI
Breads		**Breads**		**Breads**	
White bread	70	Sourdough	57	Pumpernickel	41
Wholemeal bread	72	Barley bread	65	Heavy mixed grain	30-45
French bread	95	Rye bread	65		
Breakfast Cereals		**Breakfast Cereals**		**Breakfast Cereals**	
Cornflakes	84	Cream of wheat	66	All Bran	42
Rice Krispies	82	Bran Chex	58	Toasted muesli	43
Cheerios	83	Muesli	66	Psyllium-based	
				Processed cereal	42
Potatoes	80-100	**Dairy foods**		**Dairy foods**	
		Ice cream, full fat	61	Milk, full fat	27
				Milk, skim	32
				Yogurt, low fat, fruit	33
Confectionery		**Confectionery**		**Confectionery**	
Jelly beans	80	Mars Bar	65	Chocolate (Dove)	45
Life Savers	70	Kudos whole grain	62	M&Ms	33
Skittles	70			Snickers Bars	41
Fruits		**Fruits**		**Fruits**	
Watermelon		Banana	53	Apple	36
		Pineapple	52	Orange	43
		Pawpaw	58	Peach	28
Rices (low amylose, white or brown)	70-90	**Rices** (high amylose Varieties, e.g. Basmati)	50-60	**Legumes**	
				Lentils	28
				Soybeans	18
				Baked beans (canned)	48

Reference food is as follows: glucose = 100

(d) Hypertriglyceridemia
(e) Hyperinsulinemia

(ii) In high GI diets, hyper-insulinemia is linked with all facets of the "metabolic syndrome" which include:
(a) Insulin resistance
(b) Hyperlipidemia
(c) Hypertension
(d) Visceral obesity

Thus the high GI of foods eventually may be linked with all the so-called diseases of affluence. Fasting hyper-insulinemia has been found to be an independent risk factor for coronary heart disease.

(iii) Low GI-diets are able to induce
(a) Improvements in glucose and lipid metabolism; and
(b) Reduced glycosylated proteins

(iv) Health Benefits of Low-GI food choices

Hence, guidance on appropriate food choices should, initially, be a primary goal of nutrition education for people with diabetes. We need to emphasize that all carbohydrate foods (even those containing refined sugars) are good choice, that coarsely ground flours are preferable to fine flours (whether white or whole meal), and that the consumption of slowly digested carbohydrate foods such as oats, barley, baked or cooked beans, grainy breads, fruits with low GI and are more acidic in nature, lemon juice and vinegar are all beneficial in reducing glycemic and insulinemic responses.

The challenge to the food industry is to produce new and palatable low-GI food; because many people see low-GI foods (beans and bird seed bread) as less than palatable. We therefore should encourage the development of low-GI foods for specific application in diabetes, appetite control, weight reduction and exercise. Specially formulated breads, breakfast cereals and other low-GI products will give the astitute food manufacturers a new marketing edge, with long-term benefits to public health.

Note: However, just because a food has a low GI does not mean people with diabetes can eat unlimited portions without affecting their blood glucose levels. Portions do count!

Earlier on, we have recommended that blood glucose control can be effectively managed with the use of varieties of beans that are rich in soluble fiber and are regarded as low GI food (Osilesi et al, Nig. Med. Pract. 22: 91 – 95, 1991). The potential use of beans in health and Nutrition was elucidated further (Osilesi O. Biokemistri J. 3: 83 – 102, 1993). The use of traditional fruits

and vegetables of Nigerian origin in diabetic subjects were also recommended. Their use as therapeutic adjuncts in the dietary management of diabetes (Osilesi et al Afric. J. Med. and Pharm. Sci. 1: 1 – 6, 1997), were suggested due to their content of fiber and fiber-like substances which confer anti-oxidant effects, glucose reducing effect and other anti-diabetic properties:

Furthermore, we have indicated that some food factors are important for digestibility and carbohydrate absorption; hence they can modulate glycemic response. These factors include:

(a) Nature of carbohydrate
(b) Physical form of the food
(c) Degree of cooking
(d) Fiber content
(e) Presence of protein and fat
(f) Pre-meal blood glucose

The difference, in the methods of cooking and processing; the molecular and physical characteristics of the starch in the final product may markedly influence the GI. The particle size of starchy foods has a marked effect; for as particle size decreases, the GI increases; the greater the degree of gelatinization of the starch granules, the higher the GI. No wonder then that when we experimented with starch granules in the form of Ogi-breakfast meal, a traditional corn cereal porridge, widely consumed in West Africa and prepared by fermentation, wet-milling and sieving and tested in healthy and diabetic subjects to assess the glycemic potency of starch granules with low fiber content; we observed a glycemic potency higher than that of white bread in either raw or cooked ogi and concluded that:

(i) The more processed a food is, the higher the glycemic response, due to increase in availability of starch for enzymatic digestion.
(ii) The higher the amylose-amylopectin content of starch the higher the increase in metabolic response
(iii) With cooking, the glycemic index was markedly increased, due to increased digestibility and absorption of glucose.

Our findings above (Osilesi et al, Nig. J. Physiol. Sci. 15: 20-24, 1999; Afr. J. Med and Pharm. Sci. 1: 33 – 97, 1997), agreed satisfactorily with Holms et al (Am J. Clin. Nutr. 47, 1006 – 1010, 1985) and Ross et al (Am J. Clin Nutr, 42, 631 – 635, 1987) who also affirmed a high correlation between the degree of gelatinization of starch and its digestibility in vitro and the post prandial glucose response in vivo. However, on addition of insoluble (a-cel) and soluble (Xanthan gum) fibers, to Ogi-breakfast meal, the glycemic response was high in a-cel and lowered with Xanthan gum (a soluble fibre) included in Ogi-meal

5. Biotechnological Manipulation of Ogi Breakfast Meal for Nutritional Adequacy

Whilst still reflecting on the usefulness of fiber-free or fiber-included components in Ogi breakfast products. We would like to mention some additional contributions in this area that do not particularly relate to Glycemic Index but are key additions to our knowledge of cereal nutrition. Recognizing that Ogi breakfast meal is a popular convalescence food that lacks adequate concentration of the amino acid lysine. Our research group has successfully incorporated the deficient lysine into Ogi-meal by using high lysine-producing strains of Lactobacillus plantarum as a starter culture for nutritional improvement of Ogi (Adebawo, Akingbala, Ruiz-Baba and Osilesi: Wld. J. Micro. and Biotech. 16: 451 – 155, 2000).

6. Mathematical Model for Predicting GI Worldwide

We have also successfully developed a new mathematical model using a log transformation regression analysis for predicting the glycemic index of starchy foods Worldwide (Trout, Behall and Osilesi, Amer J. Clin. Nutr. 58: 873 – 878, 1993). Evidences were given that the methods of preparing foods, the characteristic of starch and starch granules are more important in predicting GI among starchy foods than is the content of fat, protein, phytic acid and total dietary fiber in food portion containing 50g available carbohydrates.

J. USE OF ANTI-OXIDANT VITAMINS AND DF IN HYPERTENSION MANAGEMENT

We recognized early that diabetes, if left uncontrolled for years, may precipitate hypertension in predisposed individuals. Hypertension, a complex disease, causes damage to the kidney, heart and brain, thereby resulting in other cardiovascular diseases and stroke Hypertension afflicts close to 15 – 20 million Nigerians; affects more blacks than whites world-wide. It has been reported that much of the hypertension in acculturated societies are related in part to dietary habits. The majorities of hypertensive patients have only mild blood pressure increase, and can benefit significantly from dietary management alone. You may ask, "What are those dietary factors that alters blood pressure"? They are listed in Table 7

TABLE 7

STATUS OF DIETARY FACTORS IN HYPERTENSION MANAGEMENT

Dietary Factor	Benefit
Achieving ideal body weight	Always recommended
Reducing alcohol intake (< 60ml/d)	Always recommended
Reduced Sodium intake (<2g/d)	Usually recommended
Increased Potassium intake	Appears worth while
Increased Calcium	Not clearly indicated
Increased Magnesium	Not clearly indicated
Increased n-6 Polyunsaturates	Not beneficial
Increased n-3 Polyunsaturates	Beneficial
Increased intake Antioxidant Vitamins	Beneficial
Increased Fiber	Beneficial

Achieving ideal body weight and reducing excess consumption of salt and alcohol can be recommended to lower blood pressure. From a practical standpoint, this also means lowering dietary fat consumption and increasing potassium, both of which are beneficial dietary changes. Increased intake of dietary n-6 fatty acid does not appear to lower blood pressure whilst n-3 fatty acid do have some beneficial hyotensive effect. The type, amount and composition of diets appear to be relatively important in blood pressure regulation.

We have reported a lower incidence of hypertension in Vegetarians: Seventh Day Adventist [Famodu, Osilesi et al: Thrombosis Res. 95: 31 - 36, 1999; Clin. Biochem 31:545 - 549, 1998] at Ilishan Remo. However, vegetarian diets are somewhat special in regard to:

(i) Kinds and levels of fat, vegetable protein, fiber and utilizable carbohydrate
(ii) Content of n-3 fatty acids
(iii) Fiber-like contents that they contain
(iv) Anti-oxidant Vitamins level present in them
(v) High potassium cotent
(vi) Low sodium intake

The relative imortance of these dietary varibles in influencing blood pressure is far from being clear; but we have given some dietary advice in this regard and affirmed their importance in experimental and clinical studies performed at our Teaching Hospital in Sagamu.

(i) **Use of Supplemental Vitamin C Intake:** We have shown that feeding of extra Vitamin C (1000mg/d) to people in good Vitamin C status or in marginally deficient subjects; lowered systolic blood pressure and pulse pressure. (Osilesi et al; Nutr. Res 11: 405 - 12, 1991). In a simultaneous study in blacks, Vitamin C was observed to lower serum sodium and the sodium: potassium ratio along with systolic blood pressure (Osilesi et al, Nig. J. Physiol. Sciences 7: 12-17, 1991). The explanation of the mechanism of action of Vitamin C in relation to mineral effects (Osilesi, Nig. J. Nutr. Sci. 8: 83-96, 1987); the dietary energy (Osilesi, Nig. J. Nutr. Sci 9: 1-12, 1988) and the observed hypothesize effect, were clearly explained. We then postulated that Vitamin C is able to produce the hypotensive action through its antioxidant properties. It acts as the first line of defence against oxidative free radicals and lipid peroxidation reaction in the body. Hence, Vitamin C can protect against cardiovascular disease (Osilesi et al, Nig. Med. Practitioner 24: 73 - 79, 1992). Supplemental intake of Vitamin C is recommended for hypertensives to lower blood pressure and keep one in good state of health.

The current recommended dietary allowance for Vitamin C is 60mg/d for adults. The recommendation for consuming five servings of fruit and vegetables, which would provide > 200mg vitamin C/d, are poorly adhered to. The paleolithan diet has been estimated to contain 350mg Vitamin C/d, furthermore amounts > 500mg/d are indeed difficult to obtain from the diet, hence the recommendation for supplemental intake of Vitamin C to medical doctors and their patients worldwide. A supplemental intake of 1000mg/d for six week may be protective against high blood pressure and beneficial on lipoprotein oxidation. [Osilesi et al; Nig. J. Physiol Sci. 7: 12 – 17, 1991]. Use may however be harmful to patients with hyperoxaluria and a tendency to form oxalate kidney stones.

Beneficial effects of Vitamin C intake are:

(i) Increase HDL (high density lipoprotein production) which helps to resort fat located in plaques.

(ii) Decreases the production of lipoprotein (a) – a real risk factor for vascular disease.

(iii) Down – regulates cholesterol and triglyceride production in the liver.

(iv) Lowers blood sugar and insulin requirements

(v) Relaxes blood vessel wall, hence lowers blood pressure when hypertension is present

(vi) Inhibits inappropriate intravascular clot formation (the final and sometimes deadly event in cases of heart attacks and strokes).

(ii) **Fruits and Vegetables, Whole grains Protective in Maintenance of Good Health:** Since 1994 to date, special efforts were made to examine the carbohydrate contents of our traditional diets, recognizing that carbohydrates constitute, the major source of dietary energy for Nigerians. Increased intake of dietary starch and fiber are derived from root tubers, grain and cereal product, fruit and vegetables – all of which are complex carbohydrates, abundantly available in the African food staples.

Health benefits and the possible reduction of risk factors for coronary heart disease, atherogenesis, diabetes and colon cancers may be related to the increased intake in Africans of slowly or poorly digested carbohydrates, which are rich in fiber and "fiber-like" substances. In terms of intact foods' fiber serves as a marker for diets rich in plant foods.

When God created man, the Bible says that he was placed in the garden of Eden, infact, you may wonder why? Is it that God wanted man to eat more fruits and vegetables, grains and cereal products, essentially plant foods and the animals therein? Well you and I will have to answer that shortly. But what we know is that health experts now recommend that we eat at least:

(a) 3 – 5 servings of vegetables per day

(b) 2 – 3 servings of fruits per day

Why? The answer lies in the special way God has endowed the fruits and vegetables, grains and cereals for human consumption.

Vegetables and fruits, Grains and Cereals are noted to be:

√ Low in fats

√ Cholesterol free

√ Low in calories

√ Loaded with Vitamin and Minerals

√ Great sources of fiber

The good sources of fiber are vegetables, fruits, grain and cereals also contain phytochemical, and anti-oxidant vitamins, for example, a tomato contains about 10,000 phytochemical, whilst a bite of carrot serves up thousands of phytochemical and antioxidant vitamins

What are Phytochemical and the Antioxidant Vitamins?

Phytochemical refer simply to chemicals found in plants and which occur naturally in vegetables, fruits, grains, nuts and seeds. Vitamin C, Vitamin E and beta-carotene are examples of phytochemical, but are better called the antioxidant nutrients.

Sources of antioxidant rich foods are:

(a) Beta carotene

Choose yellow-orange and dark-green leafy vegetables

- Carrots, sweet potatoes, spinach, (tete) lettuce, Igbo, Ewedu, Bitter leaf (Vernonia anya dalina).
- Apricots, Cantaloupe, papayas, peaches.

(b) Vitamin C

- Cabbage, tomatoes, green peppers, potatoes, pineapple
- Citrus fruits, (oranges, grapefruits, tangerines, strawberries)

(c) Vitamin E

- Dark-green leafy vegetables

- Apples, nectarines, peaches
- Whole grain beads and cereals
- Nuts and seeds e.g. groundnut, sunflower seed

The best way to get phytochemicals and antioxidant vitamins as well as other nutrients, is to eat a wide variety of foods, including vegetables, fruits and grains.

Why are the Antioxidant vitamins so important?

Human bodies are actually battlegrounds for infection and diseases. Normal body function; such as breathing, physical activity, life style habits, such as smoking, produce substances called free radicals and other reactive oxygen/ nitrogen/chlorine species; that can attack healthy cells.

These free radicals can cause:

(a) Damage to cellular biomolecules e.g deoxyribonucleic acid (DNA) in purine and pyrimidine bases, thus causing cancers of the colon, breast, prostate and rectum.

(b) Free radicals can damage lipids especially LDL, leading to arteriosclerosis- a risk factor for myocardial infarction, stroke and vascular disease.

(c) Free radical can cause damage to proteins leading to vascular damage and to development of cancer.

Free Radical Damage

(iii) Antioxidant and Photochemical role in Body Defense

Act at various body defenses or on different oxidants or different cellular compartments.

(a) Enzymatic Antioxidant Defenses

There are a system of enzymes, including glutathione peroxidases, superoxide dismutase and catalase which decrease the concentration of the most harmful oxidants in the body

(i) Superoxide dismutases are a family of antioxidant enzymes necessary for catalytic decomposition of the superoxide radical to hydrogen peroxide and oxygen.

(ii) Catalase specifically catalyses the decomposition of hydrogen peroxide.

(iii) Glutathione peroxidases are a family of antioxidant enzymes containing selenium which are important in the reduction of hydroperoxides resulting from lipid oxidation.

FIG. 7

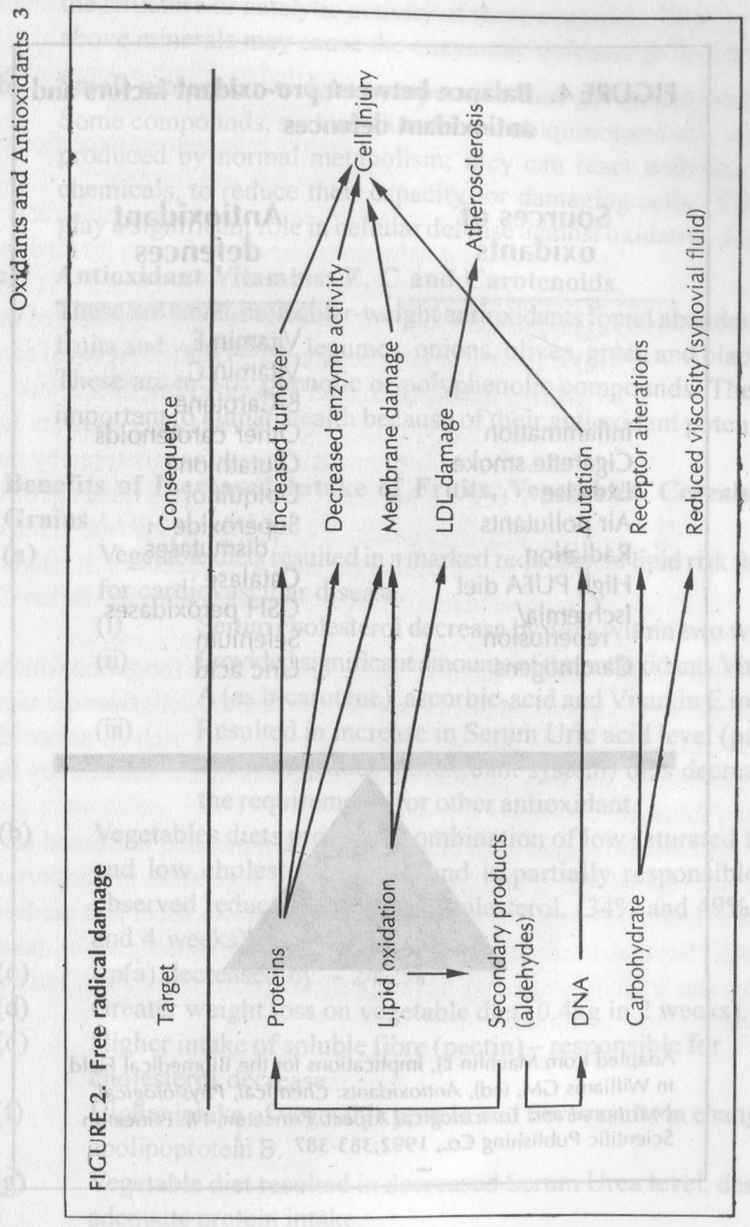
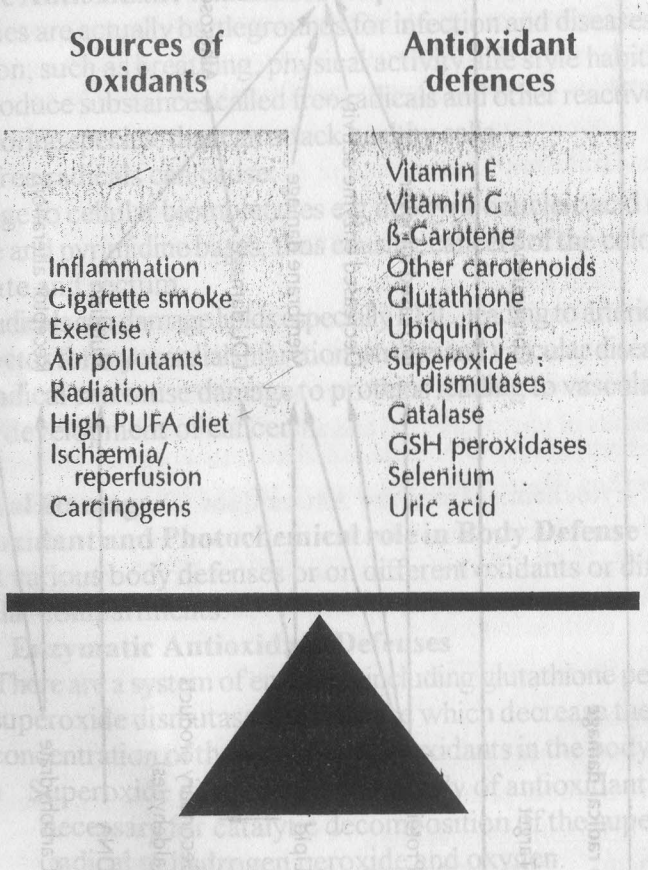


FIGURE 2. Free radical damage

FIG. 8

FIGURE 4. Balance between pro-oxidant factors and antioxidant defences



Adapted from Machlin LJ, Implications for the Biomedical Field, in Williams GM, (ed), *Antioxidants: Chemical, Physiological, Nutritional and Toxicological Aspect*. Princeton, NJ: Princeton Scientific Publishing Co., 1992;383-387

Enzymatic antioxidant defenses contain several essential minerals including selenium, copper, manganese and zinc that are involved in the structure or catalytic activity of these enzymes. Deficiency of above minerals may cause the enzymatic defenses to be impaired.

(b) **Small-molecular-weight compounds that act as antioxidants**
Some compounds, such as glutathione, ubiquinol and uric acid are produced by normal metabolism; they can react with oxidizing chemicals, to reduce their capacity for damaging cells. They all play a significant role in cellular defense against oxidative damage.

(c) **Antioxidant Vitamins: E, C and Carotenoids**
These are small-molecular-weight antioxidants found abundantly in fruits and vegetables, legumes, onions, olives, green and black tea. These are mostly phenolic or polyphenolic compounds. They are important to human health because of their antioxidant potency.

(iv) Benefits of Increased Intake of Fruits, Vegetables, Cereals and Grains

(a) Vegetable diets resulted in a marked reduction in lipid risk factors for cardiovascular disease.
- (i) Serum cholesterol decrease by 34% within two weeks.
- (ii) Provided significant amounts of the antioxidants Vitamin A (as b-carotene), ascorbic-acid and Vitamin E intake.
- (iii) Resulted in increase in Serum Uric acid level (part of the endogenous antioxidant system) thus decreasing the requirements for other antioxidant.

(b) Vegetables diets provide a combination of low saturated fat and low cholesterol intake and is partially responsible for observed reduction in serum cholesterol. (34% and 49% in 2 and 4 weeks)

(c) Lp(á) decreased by - 24.2%

(d) Greater weight loss on vegetable diet (0.4kg in 2 weeks).

(e) Higher intake of soluble fibre (pectin) – responsible for cholesterol decrease.

(f) Higher intake of vegetable protein and fibre results in change in apolipoprotein B.

(g) Vegetable diet resulted in decreased Serum Urea level, despite adequate protein intake.

(h) ↓ in Urea resulted from increased colonic fermentation due to increased fibre intake

(i) N_2 is trapped as bacterial cell protein within the human of the bowel.

(j) Diffusible ammonia is converted to difunble Ammonium ion; leading to increased fecal nitrogen elimination.

(k) ↑ Colonic fermentation results in increased excretion of the colonicall derived SCFA, acetate and formate.

(l) Vegetable diet cause significant reduction in lipids and lipoproteins; and reduction in lipid risk factors for cardiovascular diseases. [Jenkin et al: Metabolism 46: 530 – 537, (1997)].

(m) Vegetable diets can improve the immune systems of the body when human subjects consumed acceptable level of carotenoid – rich vegetables, of five servings of cooked kale, sweet potato and tomato juice. After three weeks, the subjects had a 33 percent increase in immune response as measured by the ability of their T cells to multiply. This is a good measure of immune system function because T cells play a vital role in the immune response to foreign organisms and cancer cells. (Kramer T.R Beltsville Human Nutrition Research center, Beltsville, MD, USA.)

Antioxidants, such as Vitamin C and E, and carotene foods rich which include beta-carotene, lycopene and lutein, help protect healthy cells from damage caused by free-radicals. Fruits and vegetables are not only rich in antioxidant and phytochemicals, but they possess multiple agents that could convey benefit to human (Table 8).

Agencies concerned with health have recommended increased servings of fruits and vegetables. It appears that fruits and vegetables are important to our personal health insurance and are protective against cancer and cardiovascular disease. Several nutrients present in fruits and vegetable when taken at the appropriate level of intake may have significant protective effects and a potential therapeutic role in human.

TABLE 8

"PROTECTIVE MECHANISMS OTHER THAN ANTIOXIDANTS IN FRUITS AND VEGETABLES"[a]

Compounds/Properties	Mechanisms of Action/Comments
Folic acid	Necessary for accurate DNA replication. Decreases plasma homocysteine in many subjects with elevated levels of homocysteine, which are a risk factor for cardiovascular disease.
Inhibitors of cell proliferation	Several phenolics can interfere with replication of malignant cells in vitro
Inhibitors of angiogenesis	Suggested for genistein
Inhibitors of telomerase	May promote senescence of malignant cells
Estrogen antagonism	Antagonistic action against estrogens in promoting growth of certain tumors. Suggested for isoflavonoids, such as genistein
Fiber	Increases bulk of colonic contents and decreases transit time; alters metabolism of gut bacteria to delay carcinogen formation
Stimulation of immune response	Suggested for carotenoids, including β-carotene
Caloric/fat restriction	Diets rich in fruits and vegetables have lower fat and calorie contents than meat-rich diets.
Selenium	Content in plants very variable, related to soil content. Has anticancer effect in several animal studies, probably by inducing phase II enzymes that detoxify carcinogens.
Iron chelators	Frequent suggestions but no general agreement that high body iron stores are a risk factor for cancer and cardiovascular disease. Plant phenolics and phytates are good iron chelators and may deter iron absorption from the diet.
Agents interfering with metabolic activation or promoting metabolic deactivation of carcinogens	Inhibitors of P450 (e.g. found in grapefruit juice and garlic). Inducers of quinone reductase, glutathione-S-transferases, UDP-glucuronyl-transferase and epoxide hydrolase (e.g. sulforaphane, oltipraz).
Inhibitors of cyclooxygenase (COX) (e.g resveratol)	COX involved in growth of colonic and perhaps other tumors.

[a]There may be agents not yet discovered but may serve protective functions.

K. NUTRITION AND HEALTH CARE INFORMATION

Mr. Vice Chancellor Sir, having been very lucky to serve as President (immediate past) of the Nutrition Society of Nigeria and the Editor-in-Chief for the Nigerian Journal of Nutritional Sciences (the past 10 years), I have been opportuned to promote sound nutritional practices as the keystone for promoting the Public Health of Nigerians [Osilesi O. Nig. J. Nutr. Sci 14, E1 – 5, 1999]. We have addressed the issues of National Nutrition monitoring, Nutrition Education and National Nutrition Policy, which recently became approved by the Federal Government of Nigeria. I have been involved in efforts geared at improving the eating habits, food knowledge and choices of our people, infact, evaluating the fiber content of Nigerian food staples, an area that I have earlier discussed at length. From our current knowledge, one may want to agree totally with the following dietary recommendations:

RECOMMENDATIONS

(a) Dietary Guidance

(1) Eat a nutritionally adequate diet composed of a wide variety of food.
(2) Eat less fat, particularly saturated fat
(3) Adjust energy intake for weight control; exercise regularly.
(4) Eat more foods containing complex carbohydrates and fibre.
(5) Reduce salt intake.
(6) Drink alcohol in moderation, if at all.

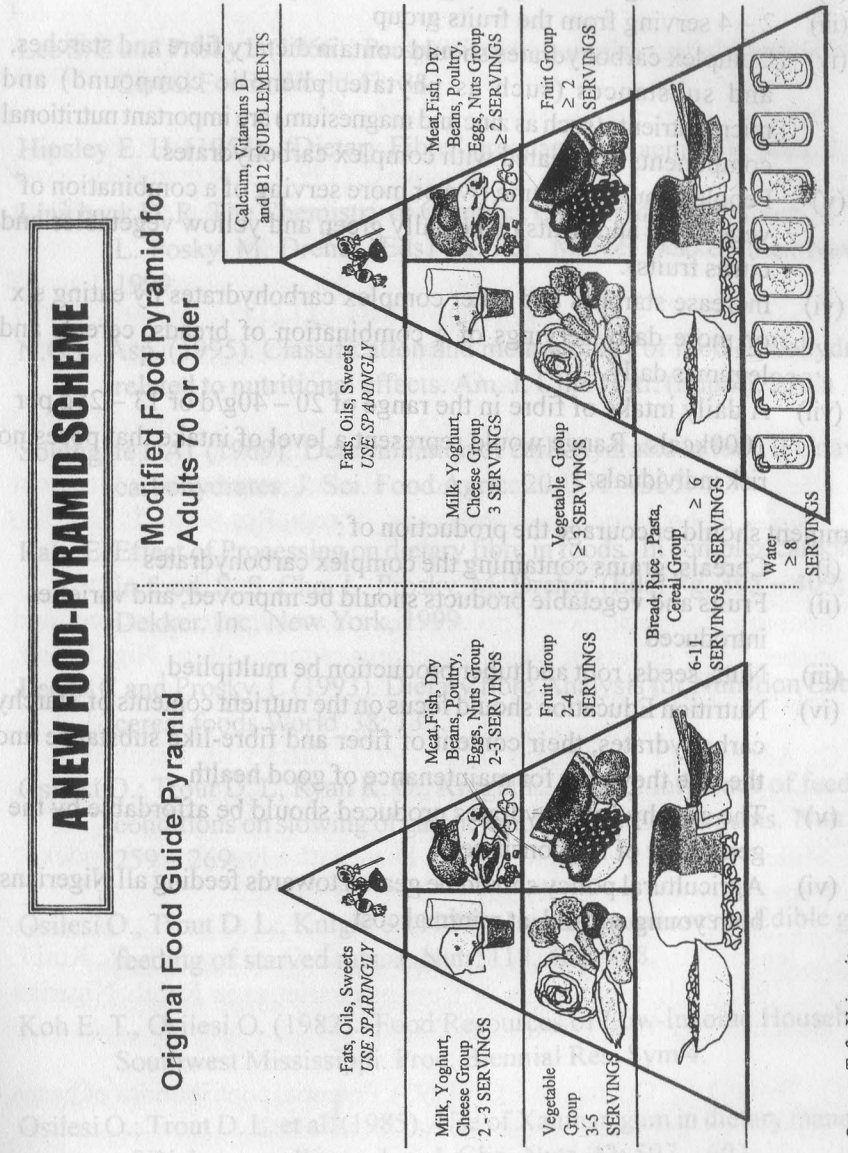
(b) The Food Pyramid Scheme

Originally designed to emphasize the importance of increased consumption of vegetables, fruits and grain products for a healthful diet and the decreased consumption of fats, sugars and alcohols. It recognized that elderly groups are particularly vulnerable to compromised nutrient intake due to decreased energy needs necessitating a decrease in food intake.

Healthy adults who are 70 and above should consume about:

(1) 8 glasses of water to prevent dehydration
(2) 6 servings or more from bread, cereal, rice group;
(3) 3 or more from vegetable group
(4) 2 or more from fruit group
(5) 3 from the dairy group
(6) 2 or more from the meat, poultry, fish, beans, eggs and nuts group.

FIG. 9



(c) Dietary Guidance for complex Carbohydrates

Food pyramid recommends:

(i) 6 – 11 servings from grain group
(ii) 3 – 5 serving from vegetables group
(iii) 2 – 4 serving from the fruits group
(iv) Complex carbohydrates should contain dietary fibre and starches, and substances (such as phytate, phenolic compound) and micronutrients (such as zinc and magnesium) are important nutritional components associated with complex carbohydrates.
(v) People should consume five or more serving of a combination of vegetables and fruits (especially green and yellow vegetables and citrus fruits).
(vi) Increase starches and other complex carbohydrates by eating six or more daily servings of a combination of breads, cereals and legumes daily.
(vii) A daily intake of fibre in the range of 20 – 40g/d or 13 – 25g per 1000kcals. Range would represent a level of intake that poses no risk individuals.

Government should encourage the production of :

(i) Cereals, grains containing the complex carbohydrates
(ii) Fruits and vegetable products should be improved, and varieties introduced
(iii) Nuts, seeds, root and tuber production be multiplied.
(iv) Nutrition Education should focus on the nutrient contents of starchy carbohydrates, their content of fiber and fibre-like substance and the role they play for maintenance of good health.
(v) The starchy carbohydrates produced should be affordable by the generality of the consumers.
(vi) Agricultural policy should be geared towards feeding all Nigerians, both young and old, at minimal cost.

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