Review

The role of food microstructure in phyto-nutrient bioavailability

1Ogori, A. F. and 2Omoniyi, S. A.

1,2Department of Home Science and Management, Faculty of Agriculture, Federal University, Gashua, Nigeria

1*Corresponding author email: ogorifaraday@gmail.com

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ABSTRACT

Nobody mucosal lining absorbs hundredth percent of all nutrients consumed, due to bioavailability issues. Foods and supplements are never completely digested to the point of releasing all of their nutrient and toxin content to the human body. Efficient bowel movement is not a function of nutrient utilization. Foodmicrostructure, a fractional frame work of cellular organelles in plant and animal play a major role in the release and bioavailability of several nutrients and allergenic substances which have great consequences in assessing nutritional role, food impact and nutraceuticals in preventing and as therapy of some chronic human diseases. The awareness and the knowledge of food microstructure are a bed foundation of applied food processing and product development for optimal mucosal and gut absorption and utilization of nutrient in human and animal blood plasmids.

Keywords: Food microstructure, bioavailability, nutrients, role of nutrients, absorption and utilization

INTRODUCTION

The well-being and health of rural and urban consumers are major concern of modern food processing industry. There has been large scientific evidence linking diseases such as CHD, cancers, diabetes and human immune viral diseases to diet. These dietrelated diseases are challenging eating habit of people, processing technology approaches ,product engineering and development and programmes (Parada and Aquila, 2007). There are many benefit and impaired health effect of food microstructure that influences nutrient in food (Parada and Aquila, 2007). However total amount of nutrient required for dieting could be found in nutritional compositional table but it availability and accessibility by gut mucosal in many cases remains uncertain and varies depending on the nature or state of food (Ogori and Utim, 2013),processing condition and presence of other component factors. The fraction of nutrient that get to the blood stream of an organism is very important but the availability of the nutrient is being influence by chemical state of the nutrient,release rate and tendency from the food matrix,nutrients interaction ,presence of inhibitors and cofactors ,formation of transition stable and unstable compounds that are rate determined based on gut metabolism (Parada and Aquila, 2007). However scientific discovery had shown that certain nutrient state, matrix condition and microstructure of food could favour or hinder nutritional responses invivo. The target of this paper is to review in a balance microstructure and food matrix molecularization and how it could affect bio–availability, bio accessibility, bio efficacy and bio–conversion of phyto-chemicals and nutraceuticals in the gut and their presence in the blood plasma.
Food Microstructure

Food produced in nature are generally organized, from molecule into assemblies or links and organelles, that are later celled and tissued. Food structure could be categorized naturally into fibrous, for example muscles, fleshy material for example tubers, fruits and vegetable, encapsulated embryo for example pulse and grains and complex fluid, for example milk. All these categorization are based on cell specialization however forming unique functionality.

Most fruits, vegetable, meat, fish, grains and tubers are eaten around the world with minor or no processing approaches with their edible microstructure being impacted by nature however the processed form have multicomponent structure matrices where protein, carbohydrate, lipids have been rearranged as either colloidal phase dispersion, emulsion amorphous or crystalline phases, gel network either by heating, cooling or by shear forces. This rearrangement could have caused negative or positive deviation of the microstructure resulting in interaction at a low level of 100um (Aquilera and Stanley, 1999). Typical microstructural element in food include cell wall starch granules, protein, water and oil droplet, fat crystal gas bubbles, foams. According to (Cuvelier et al., 2000), molecular structure of food nutrient is the smallest structural level relevant for its biological role and activity during cellular metabolism, the problem obeys Heisenberg uncertainty principle of time and scale (Kaleb 1995; Stanly, 1991) because the pseudo-plastic flow of food material in the gut varies with time and physiological factors in vivo and invitro. Matrix in food implies that nutrients are contained into a larger continuous medium that maybe cellular in origin (fruits and vegetables) microstructure which may interact with each other or media at different scale and time phases. For instance, nutrient maybe found as a molecular bound to an organelle for example, Carotenoid in carrot or entrapped in complex macromolecular matrix of starch granules and protein as ligands. Isoflavonones in baked products, isopropyl compound in onion and sulphhydrlyl in eggs.

Food microstructure and nutritional properties

Nutrients are often located in natural cellucilic compartment or in an assembled linkages during processing. In either form, the need to release them during digestion and absorption is a concern. According to (Ellis, 2004), the bioavailability of lipid in almond seed and fecal samples were discovered to have intact tissue in fecal material using a healthy object in a controlled study after feeding a subject with an almond rich diet. At the end of the day, almond tissue where found preserved after chewing and digestion. According to (Ellis, 2004), the presence of cell wall hindered the release of intra cellular lipids.

At complete disruption of micro cellular structure, full...
absorption of certain or particular nutrient may not be
certain and could depend on nutrient presence with
information with other food constituent. (Brown, 1997)
discovered that food fiber matric could decrease vitamin
A precursor absorption while ferulic acid was favorably
absorbed in the presence of brown offals (Rondini, 2004).
Food matrix have considerable influence on ionic state
nutrient bioavailability such as vitamin (Moretti, 2006)
The state of food, physical structure, ionic nature, surface area and dilution ration plays bioavailability role
in nutrient bioaccessibility, bio efficacy and bioconversion
in guts. Figure 1 above.

**Nutrient bioavailability**

The fractional ingested nutrient that is available for
utilization in normal physiological fraction and for storage
is termed nutrient bioavailability. According to FDA
nutrient bioavailability is the rat fraction of absorbed and
active available nutrient moiety or therapeutic moiety conatin in food or drugs .The concept of bioavailability is
made difficult today because of its association with efficiency and metabolic utilization of ingested nutrient
(Gregory, 2005).This could be measured in blood plasma
(in vivo) but influenced by physiology and individual
variability.

**Nutrient bioaccessibility**

This the fractional nutrient released from food matricies
and available for mucosal absorption. (Hedren et al.,
2002) defined nutrient accessibility as the amount of
ingested nutrient available for gut absorption .Not all
digested nutrient are absorbed therefore bio accessibility
could be affected by physical property of the food matric,
linking to activity of enzymes and chemical digesting
processes (Boyer and Liu, 2004)

**Nutrient bio efficacy**

The fraction of ingested nutrients that has nutrient impact
evidenced by health state of the individual .Bio efficacy
are digested nutrient that may not have nutritional effect
so could be cross linked and bounded thereby making
them unavailable. Bio efficacy is the fraction of digested
nutrient that has nutritional effect evidenced by health.

**Nutrient bio-accessibility**

Bio accessibility of nutrient can be limited by membrane
and fluid transient transport of the nutrient active
components. That efficiency of bio- active nutrient could
be impacted and this inefficiency could be overcome
when food structural matricies is well understood before
processing and digestion of food material.

**Nutrient bioequivulence**

When there exist no significance difference in the rate
and extent to which two or more active ingredient
become available at a site of active absorption under
similar molar does and condition.

**Determination of nutrient bio availability and bio accessibility**

The methods for determining bio availability and bio
accessibility are by human in vivo and in vitro
experiments. The use of in vivo experiment provides
direct data which have been used in great deals on
nutrient and foods. Usually response is measured after
consumption of pure nutrient over a reference surface
point (Nature/synthetic) living organism and compound
with equivalent nutritional dose found in a food (Yeum
and Russel, 2002). In vitro approach is measuring the
response from blood plasma concentration over time
after meal consumption. The third approach of bio
availability determination in blood plasma measurement
is after a meal is taken over extended period of days and
weeks of constant consumption of a specific food (Van
hethof et al., 1999).
The in-vitro approach requires no ethical consideration
but simulated digestion and absorption for bio availability
and bioaccessibility of digestion. All other accessory
digesting natural are synthetically and practically
employed.

**BIO availability of nutrient from plant foods**

Nutrient bio availability and bio active compounds present
in plant products are important. However food
microstructure are relevant in bio availability of several
anti-oxidant, processing such as grinding, fermentation,
ohmic heating and may improve bio availability because
of cell wall disruption to dissociating nutrient complexes
or matrices, annealing into more active molecular
structure. These could be experience vis -avis during
storage and processing of food.

**Carotenoid**

Dietary carotenoid is considered beneficial in certain
cancers and prevention of varieties of disease. The
release of carotenoid from cell wall occurs when cells are
disrupted especially using food preparation approaches, processing, masticating and not during digestion. Zhou et al. (1996) assert that food matrices may be pectin like fiber and crystalline carotenoid in carrot chromoplast which is responsible for the relative bioavailability of carrot juice incomplete release. The release of B-carotene could be aided by enzymes from spinach, however governed by sublimation in digesta (Serrano et al., 2005) (Faulk and soulthon, 2005). Cooked and puree carrot could provide bioavailability rich B-carotene for carotenoid rich food.

Lycopene

Lycopene is a carotenoid in tomatoes characterized by its red colour. Food processing like cooking heating may improve lycopene bioavailability. This approach weakens cell structure and bonding angles. Matricining enhances isomer form of Trans-form of lycopene though a naturalcis-form can be available preferably at the chylomicrons levels. Lycopene moiety are much present in tomato paste than in fresh tomatoes because of microstructure matrixing that would have released more lycopene moiety.

Xanthophylls

They are the yellow pigment of leaves. They are oxygenated carotenoid synthesized within the plastid. The other forms of Xanthophyll's accumulate in optic region and help in great deals in vision and against oxidative damage. The nutritional pigment can be made available for the blood via Lipid presence. According to (Erdman et al., 2002) Xanthophyll bio-availability is a function of its molecular structure and nutrient interaction.

Folates

Folate is one of B- vitamins required for reproduction and for new cell maintenance. Lack of folat is associated with esophageal, gastric and pancreatic cancers (Larson, 2007). Brain depression. (Abon-saleh and Coppen, 2008). Naturally folate are bound to macro molecules and disruption of folat- macro molecules structure make them unavailable for absorption either by entrapment or free unbounded state, hence unavailable, limiting them from being absorbed by absorption surfaces. Food matrixes effect reduces the load of folat absorption issues.

Polyphenols

Polyphenol is a conjugated varied compound and classes such as flavonoid, riboflavin, hydroxyl benzoic, anthocyanin (Manach et al., 2005). They are usually secondary metabolite of phenyl propanoid pathway in plant that comes by phyto-chemicals. The bioavailability of polyphenol is highly variable depending on their structure of bio channels conjugation for example sugar has 0.1% bio availability, anthocyanin in berries and red wine has 1%-5% bio availability respectively. 10%-30% for flavon and 50%-80% isoflavon (scalbert and williams, 2000) Polyphenol being sensitive to alkaline condition in the gut, bowel movement concentration moiety in target tissues varied concentration in plant tissue, cell wall structure, location of glycoside and binding matrix, (Monash et al., 2005) could easily be transformed before absorption Bermudez et al., 2007). However pancreatic digestion showed a significant role of bio availability of phenolic compound for grape seed unlike gastric and salivary digestion extract (Lau-Rent et al., 2007).

Nutrients moiety that affect bioavailability

A variety of components in foods may reduce or enhance the bioavailability of the nutrients. Some components may form complexes with a nutrient and prevent its digestion or absorption or even degrade the nutrient, as is the case with foods that contain an enzyme that breaks down the B vitamin, thiamin. Protein inhibitors that often reduce nutrient bioavailability are generally destroyed by cooking. Other complexes can increase solubility and, thus, enhance absorption.

Calcium

Efforts to understand the metabolic and dietary factors that lead to osteoporosis, or the loss of skeletal mass with aging, emphasize the importance of calcium bioavailability. Calcium in foods exists mainly as complexes with other factors (phytates, oxalates, fiber, lactate, fatty acids) from which the calcium must be released to be absorbed. Plant constituents of the diet, in particular, may reduce calcium bioavailability so that people who do not use dairy products are less likely to obtain adequate amounts of calcium. Oxalates, present in some foods, normally bind with calcium in the gut, and the body excretes both of them together, thus limiting calcium absorption and availability. Recent research has shown that the bioavailability of calcium from calcium carbonate, a widely used supplement, is similar to that from milk. It has also been shown that vitamin B6 deficiency may reduce calcium availability.

Iron

Iron deficiency is widespread in the United States and is a major cause of anemia in susceptible populations,
especially in those whose demand for iron is high, such as growing children or pregnant women. Many factors, including dietary components (phytates, tannins, phosphates, and high calcium intake), exercise, menstruation, and maturity may increase or reduce iron availability. Iron absorption and utilization increase as iron stores are depleted, but inhibiting factors in such foods and beverages as soybeans and tea can impair iron absorption. Conversely, including meat or foods containing vitamin C in a meal enhances iron absorption. It is not known how meat achieves this effect, but recent research suggests that some factors in meat form a complex with iron to increase its absorption. Meat also increases gastric acid secretion, which may increase iron availability and absorption at the gut.

The optimal criterion for measuring the bioavailability of iron is not clear. The most commonly used response criterion is hemoglobin concentration in blood. The most recent research suggests that regeneration of red-blood-cell hemoglobin can be used to measure iron bioavailability, thereby providing an easily obtainable index of iron availability.

Protocols are being developed to predict the bioavailability of iron in humans based on animal models. Recent research also shows that interactions of other minerals, such as zinc and calcium, with iron may reduce iron bioavailability. Copper deficiency, cooked meat, and raw vegetables are thought to enhance iron absorption.

**Copper**

Copper deficiency can result in anemia, bone disease, and diminished immune competence. Excessive intake of copper can lead to toxic effects, especially vascular problems such as low blood pressure and high blood-cholesterol levels. The bioavailability of copper is affected by a variety of factors. Among those which decrease bioavailability are suboptimal levels of acid in the gastrointestinal tract; the boiling of foods, which may leach away copper; and the consumption of uncooked protein foods. Copper bioavailability may also be reduced by interaction with other minerals such as iron, zinc, lead, cadmium, and selenium.

**Lead**

Intake of lead has become a major public health concern. Lead toxicity is most widespread in children, in whom it may lead to impaired mental development. In poorly nourished populations, it commonly results in anemia by interfering with the availability of essential nutrients, such as iron and copper. Recent research indicates that increasing meat intake reduces lead absorption from drinking water or other sources of ingested lead. Additional copper intake is more effective than either iron or zinc in reducing lead absorption, although intake of all three minerals seems to protect against lead toxicity.

**Vitamin B12**

Vitamin B12 deficiency rarely occurs from inadequate dietary intake but can become a problem for the elderly, leading to serious hematologic, neurologic, or gastrointestinal consequences. With age, the stomach secretes less of a protein necessary for the absorption of B12. Research indicates that pectin and other soluble dietary fibers can interfere with absorption of vitamin B12 from foods, as well as with reuse of the vitamin made available from secretions into the intestine. Inadequate knowledge of the actions of such fibers in the digestive tract, along with dietary recommendations for increased fruit and fiber intake, indicates a need for additional research.

**Folic acid (folate)**

Studies implicating folic acid in birth defects from impaired development of the spinal column and brain suggest that the recommended dietary allowances need to be reexamined as more accurate data on folate bioavailability and utilization are obtained. This will be especially critical for pregnant women. The bioavailability of folate in a typical U.S. diet is about 50 percent. An examination of folate depleted rates indicates that folate bioavailability varies from about 70 to 100 percent depending on the food source. Folic acid labeled with stable isotopes is now being used to better standardize assessments of food folate bioavailability in humans.

**Vitamin B6**

Vitamin B6 occurs in several forms in foods and is necessary for normal lipid and amino acid metabolism, red-blood-cell function, hormone production, and immune competence. The forms present in plant sources may include a complex with a glucose molecule, which appears to reduce the bioavailability of other forms of vitamin B6 present in foods. The vitamin B6 present in foods from animal sources exhibits very high availability as much as 100 percent in tuna while availability in foods from plant sources is low, 20 to 40 percent, due in part to the presence of the complex. Vegetarians are thus at particular risk for low vitamin B6 intake. Vitamin B6 status also appears to decline with age for reasons that may include reduced absorption. Research on the bioavailability of vitamin B6 is emphasizing the effects of the glucose complex in foods.
Factors affecting nutrient bioavailability

Food related factors

The bioavailability of a nutrient can in some cases be significantly influenced by the chemical form in which it appears in the diet and by the presence of other factors in food that may enhance or depress mineral absorption and utilization (Turnlund, 1999), while most vitamins are very well absorbed [from food], most essential minerals are not. Usual absorption of minerals ranges from less than 1% to over 90%. The bioavailability of dietary minerals must be considered when determining whether the diet contains enough, too little, or too much (Bronner, 1993).

Human physiology related factor

Various nutrients and dietary components interfere with the bioavailability of vitamins. Hence, requirements for vitamins cannot be considered independently, but must be evaluated in relationship to other nutrients and compounds consumed by an individual (Scalbert and Williamson, 2000). Nutrients compete with other nutrients for absorption. Some nutrients will either enhance or reduce the amounts of other nutrients being absorbed by your body. This is especially true for all the oil-soluble nutrients. The relatively tiny distal ileum or the very end of the small intestine, where it turns into the large intestine, is where most of the oil soluble nutrients are absorbed by the human body. When the ileum absorbs retinol, for example, it effectively blocks vitamin D from being absorbed.

Health status related factor

Good digestion is a requirement for natural health to work. Probiotics can be used to improve your intestinal tract health in order to enhance the bioavailability of some nutrients (Dreosti, 1993) You may also have a genetic defect that adversely affects the absorption of specific nutrients.

Negative toxin related factors

What is true for the good stuff is likewise true for all negative factors contained in your food. Just because fish is reported to contain mercury does not mean that your body will absorb most, or even any of it, any more than all the calcium content would be absorbed.

Food processing related factors

There is no best way to prepare food. Boiling food, for example, depletes more of its iodine content than baking does. Consuming fruits and vegetables raw enhances the absorption of some nutrients, whereas soaking and fermentation will increase the absorption of minerals in legumes and grains to the detriment of the water-soluble nutrients. Cooking by breaking down fiber generally increases digestibility of many nutrients, while all the oil soluble nutrients require the presence of fat for best absorption.

Matrix heterogenuity

The absorption of high lipophilic food micro constituent such as vitamins, phyto-chemical depends on fat and food matric types (Borel et al., 2003). Studies have shown that the bioavailability of heterocyclic aromatic amines from meat depend on meat doneness (Kulp et al., 2003). The heterogeneity of food matrix avidly influences bio availability of nutrient depending on the state, nature, concentrate and binding angle of that nutrient within or across the cellular pocket. This calls for understanding food matrix micro structure for developing food products.

CONCLUSION

One interesting area in food technology now is nutrient bio availability in the area of applied food science and technology. Though, certain food matrixes or cell against degradation, attaches themselves to members, occluded organelles or cell bonding but these natures protect lower bio available materials. The approach of heating mastication and digestion does not all release bio active for cellular membrane, when they are phase interaction playing it part, hence creating binding and cross binding angles to food microstructure, colloidal structure,, and chemical complexes that improves or reduce their bio availability. Food micro structure can be manipulated to our advantages by protecting nutrient extract and beneficial during storage and in man-made processmatrices.

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