Interest in foods with healthful properties has increased in recent years, because consumers are more concerned on foods that can serve as drug therapy rather than drugs with their side effects. Functional foods are regarded as foods from plants or animals (whole or processed) that come in varied forms with bioactive or functional ingredients that promote health or reduces risk of chronic or otherwise diseases, apart from provision of basic nutrients. They include whole grains, tea, coffee, cocoa, beverages, snacks, vegetables, fruits, fish, egg and egg products, soy and soy product, spices, modified oils, shrubs etc. that should be consumable at efficacious levels as part of varied diet on a regular basis. Functional food can have more than one physiological benefits due to the presence of varied bioactive components, they are categories into different classes, this reviewed some of the basis of their classification.

**Key words:** functional foods, bioactive compounds, functional ingredients, basis for classification.

**ABSTRACT**
Interest in foods with healthful properties has increased in recent years, because consumers are more concerned on foods that can serve as drug therapy rather than drugs with their side effects. Functional foods are regarded as foods from plants or animals (whole or processed) that come in varied forms with bioactive or functional ingredients that promote health or reduces risk of chronic or otherwise diseases, apart from provision of basic nutrients. They include whole grains, tea, coffee, cocoa, beverages, snacks, vegetables, fruits, fish, egg and egg products, soy and soy product, spices, modified oils, shrubs etc. that should be consumable at efficacious levels as part of varied diet on a regular basis. Functional food can have more than one physiological benefits due to the presence of varied bioactive components, they are categories into different classes, this reviewed some of the basis of their classification.

**INTRODUCTION**
There are frequent cases and challenges of health issues like diabetes mellitus, liver problem, cardiovascular diseases, cancer, kidney and aging in Nigeria and in the world at large, the sudden shift in the eating habits and culture of people, the sudden change in the lifestyle of consumers from the consumption of high caloric and unbalanced diets that can lead to emergence of severe diseases (Prakash et al., 2015). This calls for more concern on foods that can promote health or reduce risks of diseases, thereby promoting the wellbeing of human. The consumption of foods in their natural forms, fruits and vegetables whole cereal grains or those in which have additional benefits beyond basic nutrients termed functional foods. Functional foods are natural or processed foods that contains known or unknown biologically-active compounds; which is effective, non-toxic amounts, provide a clinically proven and documented health benefit for the prevention, management, or treatment of chronic disease (Functional Food Center, 2018). They are foods that have an additional benefit than providing the minimum daily requirement, which can promote health and reduce the risk of diseases due to the presence of biological active components, that ranges from whole, processed, fortified, enriched, and enhanced with nutrients, phytochemicals or botanicals, dietary supplement pre and/or probiotics constituents of processed foods that impart or promote health (Onwuka, 2014). They have been classified into a number of categories by many authors. The current review tries to bring out the basis for their classification as well as the diverse examples of these foods.

**Basis for classification of functional foods**
Functional foods can be classified according to these categories: functionality, origin, existence of functional ingredients, according to their action, strength of evidence of claim.

**a) functionality**

i) Antioxidants properties - Most phytochemicals have some antioxidant potentials (protection of cells against oxidation). Allyl sulfides in onion, leeks and garlic, carotenoids in fruits and carrot, flavonoids in fruits and vegetables, polyphenols in tea and grapes, tocopherols, carotenoids (lycopene), anthocyanin which plays a vital role in the prevention of chronic inflammatory diseases, vitamin C are known for antioxidants properties (Onwuka, 2014).

ii) Hormonal action - Isoflavones (in soybean and soy product) are also known as phytoestrogens found in plant foods with estrogen-like activity, reduce menopausal symptoms and osteoporosis (bone loss), indoles in cabbage stimulate the enzymes that make estrogen less effective. Protease inhibitors in soy and bean and terpenes in citrus fruits and cherries promote DNA replication (Onwuka, 2014).
iii) Physical action- Deals with the prevention of adherence of pathogenic microorganisms to human cell wall, urinary tracts, such as proanthocyanidins in cranberries, probiotic in certain fermented foods. Consumption of cranberries will reduce the risk of urinary tract infections and will improve dental health (Onwuka, 2014). Allicin and other sulphur compounds are major antimicrobial factors in garlic, they fight against a number of gram-negative, gram-positive and acid-fast bacteria including *Staphylococcus*, *Salmonella*, *Vibrio*, *Mycobacteria*, *Proteus* species and *Helicobacter pylori* along with antifungal, antiparasitic and antiviral activity, thus use in treatment of urinary tract infection (Cellini *et al*., 1996; Ankri and Mirelman, 1999).

b) Based on their origin
Functional foods can be from plants or animals, but plants are more important as they synthesize complex organic molecules (phytochemicals) beneficial for fortified or enhanced foods, beverages, and dietary supplements (Butt and Sultan, 2013). Others include green tea, broccoli, grape juice, cabbage, tomatoes, watermelon, psyllium, oat and barley, onion, garlic, etc. (Onwulaet *et al*., 2010).

| Plants | Plants synthesized phytochemicals that are beneficial for fortified orenhanced foods, Oat contains soluble fibre (β-glucan), soluble fiber from phylum seed husk, Soy protein and sterol and stanol-ester-fortified margarine are the ones with approved health claimed by FDA (Kathleen Meister, 2002). A recent work has confirmed an active component tannins (proanthocyanidins) in cranberries can prevent *Escherichia coli* from adhering to the epithelial cells lining and the urinary tract (Howellet *et al*., 1998). The antiadheral properties can also be of other health benefits like in oral cavity. Garlic (*Allium sativum*) possess organosulfur compounds (diallylthiosulfonate (allicin), doallyl sulfide (das), diallyl disulfide (dads) etc. (Yoo *et al*., 2014; Kodera *et al*., 2017; Yoo *et al*., 2014). Other plant based functional foods are summarized in Table 1. |

### Table 1: Plant based functional foods

<table>
<thead>
<tr>
<th>Functional components</th>
<th>Source</th>
<th>Potential benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carotenoids</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpha-carotene</td>
<td>Carrots</td>
<td>Neutralizes free radicals that may cause damage to cells</td>
</tr>
<tr>
<td>Beta-carotene</td>
<td>Various fruits, vegetables</td>
<td>Neutralize free radicals</td>
</tr>
<tr>
<td>Lutein</td>
<td>Green vegetables</td>
<td>Contributes to maintenance of vision</td>
</tr>
<tr>
<td>Lycopene</td>
<td>Tomatoes and tomato products (ketchup, sauces etc.)</td>
<td>May reduce risk of prostate cancer</td>
</tr>
<tr>
<td>Zeaxanthin (collagen hydrolysate)</td>
<td>Citrus, corn</td>
<td>Contributes to maintenance of vision and may help alleviate some symptoms associated with osteoarthritis</td>
</tr>
<tr>
<td><strong>Dietary fiber</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insoluble fiber</td>
<td>Wheat bran</td>
<td>May reduce risk of breast and/or colon cancer</td>
</tr>
<tr>
<td>Beta-glucan</td>
<td>Oats</td>
<td>Reduces risk of cardiovascular diseases (CVD)</td>
</tr>
<tr>
<td>Soluble fiber</td>
<td>Phylum</td>
<td>Reduce risk of CVD</td>
</tr>
<tr>
<td>Whole grains</td>
<td>Cereal grains</td>
<td>Reduced risk of CVD</td>
</tr>
<tr>
<td>Monounsaturated fatty acids (MUFA)</td>
<td>Olive oil, canola oil</td>
<td>May reduce risk of Coronary heart disease</td>
</tr>
<tr>
<td>Polyunsaturated fatty acids (PUFAs), Omega-3 fatty acids (ALA)</td>
<td>Walnuts, flaxseeds, flaxseed oil</td>
<td>Supports maintenance of heart and eye health and maintenance of mental function</td>
</tr>
<tr>
<td><strong>Phenolics</strong></td>
<td>Fruits</td>
<td>Neutralize free radicals; reduce risk of Cancer</td>
</tr>
<tr>
<td>Catechins</td>
<td>Tea</td>
<td>Neutralize free radicals; reduce risk of Cancer</td>
</tr>
</tbody>
</table>

Source: (Onwuka, 2014; Ndife, 2016; International Food Information Council, 1999)

Note: Other components of these foods may contribute to the potential benefits beyond the functional component listed.
ii) Animals

These include omega-3 fatty acids, predominantly found in fatty fish such as salmon, tuna, mackerel, sardines and herring. Two types of omega-3 fatty acids exist: Docosahexaenoic acid (DHA) for proper functioning of brain and eye and Eicosapentaenoic acid (EPA) used as an infant formula (Kris-Etherton, 2000; Agency Response Letter, 2002), modified oils, conjugated linoleic acid etc. (Table 2).

Table 2: Animal based functional food

<table>
<thead>
<tr>
<th>Functional Food</th>
<th>Bioactive compound</th>
<th>Potential benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmon, tuna, marine and other fish oils</td>
<td>PUFAs, omega3 fatty acids (DHA, EPA)</td>
<td>May reduce risk of coronary heart disease, support maintenance of eye health and mental function (International Food Information Council, 1999)</td>
</tr>
<tr>
<td>Beef and lamb, some cheese</td>
<td>Conjugated linoleic acids (CLA)</td>
<td>Reduce breast cancer, maintenance of desirable body composition (Hasler, 2002; International Food Information Council, 1999)</td>
</tr>
<tr>
<td>Fermented dairy products</td>
<td>Probiotic</td>
<td>Support gastrointestinal health, boost immunity (Thushara et al., 2016; Ryan et al., 2015)</td>
</tr>
</tbody>
</table>

c) Based on existence of bioactive or functional ingredients

i). Unmodified - These are foods with naturally occurring functional components for health promotion. They include tomatoes with lycopene associated with a decreased prostate cancer (Chen et al. 2015), and also allicin, diallyl sulfide, and diallyl disulfides in garlic (Lawson and Gardner, 2005; Gupta et al., 2015), quercetin in onion prevent heart diseases (Brull et al., 2015), Quercetin-3-O-glucoside also in onion is an anti-inflammation (Sekhon-Loodu et al., 2015), grains (whole wheat, barley, oat meal) high in dietary fiber for lowering cholesterol and helps in controlling blood pressure, nuts (cashews, almonds) which are good sources of magnesium, that can manage blood pressure, fish (sardines and salmon) lower in mercury and high in omega-3 fatty acids which lowers risk of heart diseases, whole fruits (African star apple, guava, with high radical scavenging ability (Oboh et al., 2015)), vegetables; guava leaves, bitter leaf, moringa leaf (Acham et al., 2018), legumes, dairy, meats etc.

Table 3: Functional food from Natural source (Unmodified)

<table>
<thead>
<tr>
<th>Functional Foods</th>
<th>Functional Components</th>
<th>Potential Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomatoes, Watermelon</td>
<td>Lycopene</td>
<td>Lower risk of prostate cancer (Chen et al., 2015; Hasler, 2002)</td>
</tr>
<tr>
<td>Citrus</td>
<td>Flavonones</td>
<td>Reduce drisk of some cancers (Wang et al., 2015; Liang et al., 2014; Song and Bae 2013)</td>
</tr>
<tr>
<td>Cranberries</td>
<td>Proanthocyanidins</td>
<td>Lower risk of urinary tract infection (Micali et al., 2014; Vasileiou et al., 2013)</td>
</tr>
<tr>
<td>Fatty fish</td>
<td>Omega-3 fatty acids</td>
<td>Reduced risk of cardiovascular disease (Chowdhury et al., 2012)</td>
</tr>
<tr>
<td>Whole grain foods</td>
<td>Bran/fiber</td>
<td>Reduced risk of cardiovascular disease, cancer, and mortality from all causes (Aune et al., 2016)</td>
</tr>
</tbody>
</table>

Note. These functional foods may contain more than one functional components with varied potential benefits than those listed in the table above.
ii) Modified (added to/ removed from) - These consist of processed foods in which a component is added to the food to give it additional benefits (Table 4). The processes involve enhancement, enrichment and fortification of foods with a bioactive or functional ingredients. For example, Omega-3 enriched eggs contained the omega-3 fatty acids as a bioactive food ingredient, where the hens are fed with high proportion of ingredients that contain omega-3, such as flaxseed, which reduce the risk of fatal coronary heart disease (Del Gobbo et al. 2016). Other examples include orange juice with added vitamin D (Tangpricha et al., 2003; Biancuzzo et al., 2010), breads with added fiber (Olubunmi et al., 2015; Lin et al., 2009; Rosell et al., 2006; Penella et al., 2008; Ndife et al., 2011), fortified cereals, and a wide variety of other food products.

Table 4: Modified Functional foods

<table>
<thead>
<tr>
<th>Functional Food</th>
<th>Functional Ingredient</th>
<th>Potential Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange juice with added vitamin D</td>
<td>Vitamin D</td>
<td>Reduced risk of bone diseases</td>
</tr>
<tr>
<td>Yoghurt with a probiotic</td>
<td>Probiotic</td>
<td>Gastrointestinal wellness, ant carcigenesis, (Sakar, 2010; Sakar, 2013)</td>
</tr>
<tr>
<td>Breads with added fiber</td>
<td>Fiber</td>
<td>Alleviates constipation (Ndife et al., 2011)</td>
</tr>
<tr>
<td>Fortified Margarine Functional beverages</td>
<td>Plant stanol or sterols esters Probiotics, Prebiotics and Symbiotic</td>
<td>Reduces cholesterol level prevention and therapy of health conditions (Nazhand et al., 2020)</td>
</tr>
</tbody>
</table>

Iii) Functional ingredients- are bioactive compounds that can be used in the manufacture of functional food products. These bioactive compounds can be obtained from a variety of sources such as primary produce, marine sources, microorganisms and inorganic raw materials. These are isolated or synthesized food ingredients with functional components. Examples indigestible carbohydrates, resistance starch, that provide prebiotic effect

d) According to their action
i. Vitamins and minerals fortification (e.g., vit C, folic acid, calcium, iron).
ii. Cholesterol reduction (e.g., omega-3 fatty acids, phytosterols).
iii. Dietary fiber (e.g. non-digestible carbohydrates and lignin).
iv. Probiotics, prebiotics, and symbiotic (e.g., yoghurt, kefir, fruits, vegetables).
v. Phytochemicals (e.g., phenolic compounds, carotenoids, lycopene) (Roberfroid, 2000)

e) Strength of claimed-classifies the strength of the scientific evidence for the benefits of various functional foods currently on the market as follows (Kathleen Meister, 2002):.
i. Very strong evidence-whole oat products (lowered cholesterol levels and reduced heart disease risk), foods containing psyllium (lowered cholesterol levels and reduced heart disease risk), whole soy foods and foods made with soy protein (lowered cholesterol levels and reduced heart disease risk), special fortified margarines made with plant stanol or sterol esters (lowered cholesterol levels and reduced heart disease risk), sugarless chewing gums and candies made with sugar alcohols (do not promote tooth decay). The FDA has approved health claims for all of these products.

ii. Strong: Fatty fish containing omega-3 fatty acids (reduced risk of heart disease).

iii. Moderate: Cranberry juice (reduced risk of urinary tract infection), organosulfur compounds in garlic (lowered cholesterol levels).

iv. Weak to moderate: Green tea (reduced cancer risk), lycopene in tomatoes and tomato products (reduced risk of some types of cancer, especially prostate cancer

v. Weak: Dark-green leafy vegetables containing lutein (reduced risk of macular degeneration), meats and dairy products containing conjugated linoleic acid (various health benefits), cruciferous vegetables (reduced cancer risk), probiotics (beneficial effects on gastrointestinal function and immunity).

CONCLUSION

Here are some of the basis for classification of functional foods, but still other categories can exist by different authors based on some varied bases depending on the understanding of what functional food meant. It is therefore recommended to take whole/natural foods at required amount for a varied period of time for the provision of physiological benefits to the human’s health.
REFERENCES


Functional food Center (2018). Definition of Functional foods


