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BASIS FOR CLASSIFICATION OF FUNCTIONAL FOODS: A REVIEW

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ABSTRACT
Interest in foods with healthful properties has increased in recent years, because consumers are more concern on foods that can serves as drug therapy rather than drugs with their sides 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 in to different classes, this reviewed some of the basis of their classification.
Key words: functional foods, bioactive compounds, functional ingredients, basis for classification,

INTRODUCTION

There are frequent cases and challenges of health issues like diabetes mellitus, liver problem, cardiovascular diseases, cancer, kidney and ageing 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 in to 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 food. 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 orenhanced 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. (Onwulata*et al.,* 2010).

i) Plants

Plants synthesized phytochemicals that are beneficial for fortified orenhanced foods, Oat contains solublefibre(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 (Howell*et al,* 1998). The anti adheral 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

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

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 formular (Kris- Etherton, 2000; Agency Response Letter, 2002), modified oils, conjugated linoleic acid etc. (Table 2).

Table 2: Animal based functional food

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

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)

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

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 flax seed, 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

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

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., yoghourt, 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.

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