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Functional Foods and the Gut Microbiome

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Introduction

Functional foods are foods that have functional (naturally occurring, biologically active) components, which tend to confer health benefits far more than ordinary nutrition. It was reported that the components are crucial in the prevention of disease.1 Functional foods, as defined by Health Canada, are products that look like tradi-tional foods but are proven to offer some physiological benefits. The combination of foods with some herbal medicines forms the basis for most outstanding traditional functional foods. Functional foods include the following: Foods enhanced with biologically active substances (for example, probiotics) and Derived food compounds added to conventional foods (for example, prebiotics). Normal foods containing inherent biologically active substances (for example, dietary fibre, dietary poly-phenol, phytochemical). Functional foods show some similarities in appearance with conven-tional foods. Still, functional foods exhibit physiological advantages with the ability to diminish the danger of constant sickness past essen-tial dietary capacities, including support of gut well-being, unlike conventional foods.2 Probiotics as functional food Probiotics, as defined by FAO/WHO in 2001, are live microorganisms that on ingestion in the right proportion confers a health benefit on the host. The probiotics concept was hypothesised by Elie Metchnikoff 1900 years ago after he observed that the Bulgarian peasants live

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Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria. longer and healthier, which was traceable to the intake of products associated with fermented milk. He noted that organisms that shield the gut from the destroying impact of other harmful bacteria are pre-sent in yoghurt. Due to their preventive and curative properties, a series of beneficial microbes have gained usage over the years as pro-biotics both in human and animal feeds formulation.3 Criteria for selecting probiotics The primary criteria in selecting suitable bacteria species include ade-quate dose, ability to remain viable with processing and during stor-age, ability to survive intestinal transit, and aspiring health impacts on consumers.4 Locally fermented foods as potential probiotics vehicles Fermented foods form part of the foremost African food. The fermen-tation process describes the anaerobic breakdown of organic substrates into acids or alcohol through the action of enzymes produced by mi-croorganisms, majorly bacteria, and yeasts.5 Fermentation helps in

nutritional enhancement, health stimulating, flavour addition, and food preservation.6 Fermentation contributes to the development of the nation's economy by creating diverse food for constant availability, increases farmers' income, and causes a reduction in harvest losses.7 Some of the locally fermented foods in Nigeria include; Iru from lo-cust bean (Parkia biglobosa), Ugba from oil bean seed (Pentaclethra macrophylla),8 Garri from cassava (Manihot esculenta), Lafun from cassava (Manihot esculenta), Ogiri from melon seed (Colocynthis citrullus, Coloncythis vulgaris),8 Amasi, Banu, Ogi, Injera, Mahewu and Kunu. Lactic Acid Bacteria (LAB) have been shown by several studies to be present during the fermentation of many African indige-nous foods.9 Aside from the regular role they play during fermenta-tion, lactic acid bacteria have also been shown to have a series of ap-plications in food fermentation products that have health benefit when consumed by individuals across the globe.9 A specific strain of LAB often play the role of probiotics when present adequately in a diet, and this has given them relevance in the industries and in some optimised local fermentation processes where they are being used as starter cul-tures.10 ARTICLE I NF O ABSTRACT Article history: Received 28 August 2020 Revised 03 November 2020 Accepted 23 November 2020 Published online 30 November 2020 The diversity of microorganisms that inhabits the gut play vital roles as determinants of human health. Among other factors, diet has a significant impact on gut microbial composition and function. This is as a result of the biotransformation of food components and the production of metabolites by the microorganisms. Examples of gut microbiota include Bifidobacterium, Lac-tobacillus, Streptococcus, Saccharomyces cerevisiae. The interplay between the diet, gut micro-biota, and the host occurs as the diet changes the gut microbiota composition and function, which in turn affects the host biochemical processes. Thus, diet is currently considered one of the most critical factors that control microbiota structure and metabolism. Functional foods such as probiotic products, prebiotics, symbiotic and dietary polyphenols can modulate the microbio-ta. This is a result of the health benefits associated with these foods. More knowledge of the interactions between functional foods and specific intestinal bacteria could contribute to a better understanding of both positive and negative interactions in vivo and the identification of new microorganisms inhabiting the gut. Keywords: Probiotics, Prebiotics, Synbiotics, Gut microbiota.

Trop J Nat Prod Res, November 2020; 4(11):861-865 ISSN 2616-0684 (Print) ISSN 2616-0692 (Electronic) Prebiotics as functional food Prebiotics are short-chain carbohydrates (SCCs) that cannot be digest-ed by human digestive enzymes.11 They are a non-metabolisable food component that transits to the colon, where it undergoes fermentation by selected microorganisms.11 The host gain from this when it selec-tively permits the growth of one or more useful microbes. Prebiotics definition somehow resembles dietary fibre definition, but it differs because of its preference for large groups of resident microbes. Pres-ently, only non-digestible carbohydrate (CHO) molecules (disaccha-rides, oligosaccharides, polysaccharides), resistant starches, and sugar polyols have been shown to exhibit prebiotic properties. Commonly used prebiotics in human diets includes; Lactulose, Galactooligosac-charides(GOS), Fructooligosaccharides (FOS), inulin and inulin hy-drolysates, Maltooligosaccharides, and Resistant starch. Synbiotics as functional foods Prebiotics has limited capacity in the sense that it can influence the growth of only available bacteria in the large intestine. In contrast, probiotics are the species introduced that have to compete for

nutrition and conditions available for growth with the resident commensal or-ganisms. Resident microbes already inhabit most of the ecological niches present, thereby making it hard for newly introduced probiotics to thrive and be established. Based on this simple fact, synbiotics was developed, which is the mixture of both probiotics and prebiotics. The rationale behind this being that when the right proportion of probiotics and prebiotics are present, prebiotic should help probiotics to thrive well in the gut until they are established.12 Synbiotics are being used in food product formulation to maximise their synergic effects. Dietary polyphenols as functional foods Dietary polyphenols are naturally occurring compounds in plants like fruits, vegetables, cereals, wine and coffee. Based on their structure and chemical compositions, they are classified into flavonoids and non-flavonoids.13 Flavonoids are divided into flavones, dihydroflavo-nols, flavonols, flavonols, anthocyanidins, isoflavones and proantho-cyanidins. It is widely known for its antioxidant, anti-inflammatory, anticancer and neurone protection properties. Fruits such as apple, pineapple, avocado, grapes, guava, pomegranates to mention but few are good sources of polyphenols. Microbiota and microbiome Humans have been tagged one of the most complex living unit owing to evolution. Microbiotic cells form the more significant part of the total human cells with up to 10 to 100 trillion residing within a single individual, thereby forming up to fifty per cent of the total cell count.14 The microbiome is referred to as the microbial occupant of a popula-tion.15 Microbiome connotes the community of commensal, symbiotic and pathogenic microorganisms competing with our body space and has a great impact on the determination of well-being and disease.16 Microbiota means a microbial community; commonly described based on the habitat that it occupies while microbiome is the total genomes and genes found among the members of microbiota.17 Gut microbiota Numerous populace of microorganisms colonised the human gut, predominantly bacteria as evaluated, a grown-up adult is made up of 100 trillion cells in their microbiota, which makes it exceed the whole of human cells by 101.19 It was reported that the ability of the intesti-nal microbiome to carry out the function of metabolism is roughly 102-times more prominent than that of the human liver and is traceable to the consequence of the incredible assorted variety of microorgan-isms framing the populace and thus the number of genes present in them.20 Functions of the gut microbiota Mutualistic relationship exists among the gut microbiota and the hu-man host, and the bacteria assist in the homeostatic regulation of the host body while the host intestine creates a suitable environment that supports the growth of the bacteria.21 Figure 1: Microorganisms occupying different parts of the gut and their abundance.18 It was reported that the gut microbiota play a crucial role in digestion, absorption and energy production as well as the production of vita-mins K2, folate and short-chain fatty acids (SCFAs) for the host.22-24 Other functions of the gut microbiota include building and boosting of the intestinal immune system, secretion of antimicrobial products which act against pathogenic bacteria, maintaining gut integrity, utilis-es non-digestible ingredients from food, producing nutritional factors such as Vitamins, detoxifying the malicious xenobiotics and influenc-ing the host health.25 These functions are indispensable, because with-out gut microbiota or with its removal with wide range anti-infection agents, the noticeable problem can occur, for example, inappropriate build-up of the intestinal immunity and the development of gut patho-genic organisms.25 The gut microbiota is crucial in digestion, and it shows some variation at each anatomic site of the gut which is as a result of change in some factors such as temperature, pH, redox potential, oxygen tension, wa-ter activity and light.26 The gut microbiota plays its role mostly in the colon where there is no secretion of digestive enzymes to carryout metabolism of indigestible macronutrients in the ileum.26,27 Polysac-charides and oligosaccharides form the primary indigestible macronu-trients which are later fermented by the

commensal bacteria of the colon thereby leading to the production of short chain fatty acids (SCFAs) and phenolic compounds which are further metabolised to produce or synthesise bioactive compounds.27 Bacterial proteinase and peptidase produced by some species like Propionibacterium spp., Clostridia spp., Prevotella spp., Bifidobacterium spp. and Bacteroides spp. aid the fermentation of protein in the colon.26,27 Gut microbiota also helps in determining brain health. It was reported that mood, memory and also cognition could be affected by gut mi-crobiota and it has been clinically and therapeutically associated to some disorders such as alcoholism, restless leg syndrome, fibromyal-gia and chronic fatigue syndrome.28-30 Alteration in the gut microbi-ome composition are communicated to the central nervous system through the vagus nerve, and this have a direct effect on cognition, behaviour and stress reactivity.31 Neurotransmitters like noradrenaline, serotonin, acetylcholine and gamma-aminobutyric acid (GABA) can be synthesised by gut microbiota and this may increase the neuro-transmitter levels in the CNS which affect the performance of the CNS.32-34