BIBLIOGRAPHIC INFORMATION SYSTEM

Journal Full Title: Journal of Biomedical Research & Environmental Sciences

Journal NLM Abbreviation: J Biomed Res Environ Sci

Journal Website Link: https://www.jelsciences.com

Journal ISSN: 2766-2276

Category: Multidisciplinary

Subject Areas: Medicine Group, Biology Group, General, Environmental Sciences

Topics Summation: 128

Issue Regularity: Monthly

Review Process type: Double Blind

Time to Publication: 7-14 Days

Indexing catalog: Visit here

Publication fee catalog: Visit here

DOI: 10.37871 (CrossRef)

Plagiarism detection software: iThenticate

Managing entity: USA

Language: English

Research work collecting capability: Worldwide

Organized by: SciRes Literature LLC

Manuscript should be submitted in Word Document (.doc or .docx) through

Online Submission

form or can be mailed to support@jelsciences.com

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JOURNAL OF BIOMEDICAL RESEARCH & ENVIRONMENTAL SCIENCES
ISSN: 2766-2276
SUBJECT AREA(S): NUTRITION
DOI: 10.37871

REVIEW ARTICLE

Health Benefits of Functional Foods

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ABSTRACT

Functional foods, also so-called supefoods being rich sources of many bioactive with attributed health-promoting properties, play important roles in disease prevention and may support treatments applied in certain chronic conditions and metabolic disturbances. To date, epidemiological evidence obtained from observational studies and clinical trials demonstrated that the regular consumption of nutrient-rich foods, particularly those of plant origin can increase vitality, bring benefits for overall health and reduce the risk of chronic disease. These benefits are predominantly linked to improved metabolic health, reduced inflammation, and body weight management. Furthermore, there is also increasing evidence that some of those products, like fermented foods, berry and tea beverages may also support mental health if consumed as part of a daily diet. Finally, some of the dietary superfoods are also recognized by cosmetic industries, which more often incorporate bioactive from these foods into cosmetic formulations or recommend dietary supplementation to improve skin condition.

Introduction

Functional foods, whether, processed or not play an important role in the prevention of chronic diseases, while supporting general wellbeing of communities. The health benefits attributed to certain foods are attributed to their rich content of bioactive ingredients, with specific biological properties and effects for the human physiology. Although certain foods are naturally high in health-promoting nutrients, there is also growing interest in developing processed functional products through of which the most common examples include enriched foods, such as calcium - enriched milk, enriched juices with omega-3 fatty acids, yoghurt with probiotic organisms and phytosterol-enriched margarines [1]. These foods although may look similar to the commercially available foods, during the production process have been added with ingredients with confirmed beneficial properties and designed to address a special nutritional need of the particular customer group. This can be achieved by increasing content of bioactive components which previously have been associated with beneficial health effects, for example omega-3 fatty acids, vitamins (vitamins A, C and E), minerals (selenium, zinc), pro/pre-biotics, antioxidants (coenzyme Q10, polyphenols, anthocyanidins, flavonoids, β-carotene, lycopene), essential amino acids, polysaccharides and others [1].

Nutraceuticals are food components that have demonstrated beneficial effects on the health outcomes; however, they are not necessary for the normal maintenance. Nevertheless, there is a growing evidence to demonstrate that presence of nutraceuticals within the daily diet may play a beneficial role in modifying and maintaining normal physiological function [2]. Consequently, nutraceuticals are a part of a complex diet, in particular if that diet is based on whole foods, mostly of plant origin. Although observations conducted in populations following a plant-based well-balanced diets support the beneficial effects of regular nutraceuticals intake, the efficacy in establishing significance of these effects can vary, depending not only of the consumer, but also quality, type and preparation/processing methods of the consumed food sources. For these reasons, it is often extremely challenging to conduct the dietary clinical trials on particular nutraceutical to prove their efficacy or demonstrate mechanism of action [3].

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Submitted: 21 October 2022
Accepted: 09 November 2022
Published: 10 November 2022

DOI: 10.37871/jbres1598

MEDICINE GROUP

NUTRITION

VOLUME: 3 ISSUE: 11 - NOVEMBER, 2022

How to cite this article: Jurek JM. Health Benefits of Functional Foods. 2022 Nov 10; 3(11): 1307-1316. doi: 10.37871/jbres1598, Article ID: JBRES1598, Available at: https://www.jelsciences.com/articles/jbres1598.pdf

Superfoods are examples of the various foods, of both animal and plant origin, that being a rich sources of nutraceuticals, may contribute to the prevention of the metabolic syndrome, since many of these foods contain potentially bioactive ingredients [4]. Conceptually superfoods are foods that are high in nutritional value; with additionally have satisfactory bioavailability and bioactivity within the body [1]. Some of superfoods examples present in typical diet, with the confirmed beneficial properties include tea, blueberries and other berries, walnuts, oats and many others [1]. As these foods are excellent source of healthful compounds that have been implicated in disease prevention and health promotion, including anti-oxidants such as anthocyanins, flavonoids, phenolics, which may help to decrease risk of common chronic conditions, such as metabolic syndrome, cardiovascular diseases, diabetes or obesity, as well as delay progressive aging [4].

Recent studies investigating health benefits on including superfoods within the daily diet demonstrated that they regular consumption is able to increase vitality, as well as improve the overall health and reduce risk of chronic disease. Recent evidence-based overview of the effectiveness of medicinal plants demonstrate that certain several species, commonly used as herbs and spices, may have the potential to benefit diabetes management, as they have been shown to improve glycemic control. This effect determined by the HbA1c reduction is the most noticeable for Aloe vera, Psyllium fibre and Fenugreek seeds, while more research needs to be done for other plants. It is worth to add that these effects were observed with at least 3 months follow-up [5]. Owing the growing interest in the functional foods, as well as so-called superfoods, the main aim of this review is to assess the recent evidence of commonly consumed conventional foods with potential health benefits and evaluate their health-promoting and preventive potential.

Beneficial Effects of Plant Foods for Metabolic Health

Effects of various superfoods including plant extracts, fruits, herbs and spices as well as fermented products have been clinically tested for use in diabetes management, owing to their potential anti-diabetic functions, however the results obtained from these studies showed various degrees of effectiveness in preventing the disease.

Herbs and spices

Fenugreek: Fenugreek is a herb that is widely used in cooking and as a traditional medicine for diabetes in Asia as a source of benefits for health active compounds, such as trigonelle, diosgenin, 4-hydroxy isoleucine, as well as dietary fibers and saponin which are responsible for hypoglycemic properties of the plant. Fenugreek has proven benefits for metabolic health, including improvements in glycemic control and lipid profile: Meta-analysis conducted on 10 clinical trials which involved dietary intervention with medium or high doses of fenugreek in diabetes for at least a week in duration, demonstrated that intake of fenugreek seeds can significantly improve glycemic control, by decreasing fasting blood glucose, 2h post-load glucose as well as help with long-term management of glycemia determined as decreased levels of glycated haemoglobin [6]. Supplementation with 1 mg of extract from fenugreek seeds after 2 months significantly reduced blood glucose and insulin levels, as well as improved insulin resistance followed by months of improved lipid profile, which has been observed as a decrease in triglycerides concentration and increased HDL cholesterol levels in type 2 diabetic patients, compared to control group receiving placebo [7].

Cinnamon: Cinnamon extracts are a source of various phenolics, also polyphenol type-A polymers that have demonstrated insulin-mimetic properties. Consequently, supplementation with 1 g of cinnamon powder of 1 g a day, reduced blood fasting glucose concentration and improved the blood lipid profile in postmenopausal women diagnosed with type 2 diabetes [8]. Similarly, clinical intervention with the dietary supplement Cinnulin PF®, with a dose of 500 mg a day, is equal to 10 g of cinnamon powder after 12 weeks significantly reduced fasting blood glucose levels compared to placebo in individuals with metabolic syndrome [9]. Also, adding a 6 g of cinnamon to the 300 g portion of rice pudding, consumed daily, has been shown to reduce postprandial blood glucose and delayed gastric emptying, however without affecting the satiety, compared to consuming a 300 g portion of rice alone [10].

Curcumin: Curcumin sourced from the roots of turmeric, is one of the richest sources of potent bioactive compounds with antioxidant, anti-inflammatory, and antimicrobial properties, linked with many health benefits, including diabetes prevention. For example, curcumin supplementation for a period of at least 9 months has been shown to lower the risk of diabetes, which was explained by curcumin ability to enhance the general capacity of pancreatic β-cells [11]. Curcumin supplementation over at least or more than 12 weeks can significantly improve glycemic control, leading to a reduction in both fasting blood glucose and glycated hemoglobin HbA1c levels, as well as improving insulin resistance in patients with type 2 diabetes [12]. Furthermore, supplementation of curcumin in the form of capsules providing 1500 mg curcumin powder a day, after 10 weeks reduced complications associated with diabetes and decreased triglyceride and of CRP concentration compared with the control group [13]. A 6-month long intervention with the same dose of 1500 mg a day of curcumin extract significantly lowered the atherogenic risks in patients with type 2 diabetics aged above 35 years, observed as a reduction in pulse wave velocity, and increased level of serum adiponectin, while decreasing level of leptin [14].

Ginger: Ginger is known to contain a number of various bioactive compounds known as gingerol, shogaol, zingerone and paradol, which have been reported with potential beneficial effects for patients with type 2 diabetes. Results of a meta-analysis conducted on clinical studies investigating glycemic control in type 2 diabetics, indicated that supplementation with ginger extracts with doses ranging between 1600 and 4000 mg a day, could significantly improve long-term glycemic status determined by glycated haemoglobin HbA1c levels when compared to the baseline [15]. Supplementation of 2 g a day of ginger powder after 12 weeks can significantly reduce levels of both fasting blood sugar, and glycated haemoglobin HbA1c, as well as oxidative stress determined by reduced malondialdehyde levels in patients with type 2 diabetes [16]. Similarly, supplementation with 2 g of ginger powder after 12 weeks significantly decreased glucose levels followed by reductions in BMI and waist circumference in the group of obese women [17,18]. Also, a 1.6 g dose of ginger powder after 12 weeks was effective in significantly decreasing glucose concentrations in type II diabetics [19]. Furthermore, supplementation with capsules containing 3 g of ginger powder capsules after 45 days significantly reduced triacylglycerol levels in hypercholesterolemic individuals [20]; whereas intake of dietary supplements providing a 1.6 g of ginger powder after 12 weeks also significantly reduced triacylglycerol levels in type II diabetics [19].

Finally, ginger extracts being a rich source of functional bioactives, has demonstrated potential anti-aging, skin-whitening, and anti-inflammatory properties. For example, compound 1,1-diphenyl-2-picrylhydrazyl (DPPH) obtained from the ginger extract possess the inhibitory ability to reduce free radical formation and promote collagen synthesis, which may bring promising value for anti-aging natural skincare [21].

Garlic: Garlic, formally a vegetable with characteristic flavor attributed to various bioactive sulfur compounds have been shown to bring benefits metabolic health. Dietary supplementation of tablets providing 600 mg of garlic powder tablets a day after 12 weeks significantly increased HDL cholesterol in type II diabetics [22]. Similarly, supplementation with capsules containing 900 mg of garlic powder after 24 weeks was effective in reducing and glucose concentrations in diabetics patients [23] supplementation with tables providing from 600 to 1500 mg of garlic powder after 24 weeks helped to reduce both systolic and diastolic blood pressure in hypertensive individuals [24].

Cannabis (CBD): The Cannabis plant has been cultivated and used for its medicinal and industrial benefits dating back to ancient times. Cannabis sativa and Cannabis indica are the main species of the plant, which contains more than 80 different bioactives, known as cannabinoids. The most abundant cannabinoid, Tetrahydrocannabinol (THC), is well known for its psychoactive properties, whereas Cannabidiol (CBD) is the second most abundant and is nonpsychoactive [25]. Although CBD has a chemical structure similar to THC, it demonstrate different properties, explained by differences in the ability to bind rCB receptors. For example, THC having a planar structure is binding to the rCB_1, while CBD has a slightly angular structure that hampers its ability to bind to this receptor. As the consequence, CBD displays 100 times less affinity for rCB_1 than THC, which justify opposing CBD properties to THC, reflected in both pre-clinical and clinical research showing that CBD did not induce euphoria or intoxication in healthy volunteers [26]. In individuals suffering from Generalized Social Anxiety Disorder (SAD), a common anxiety condition, a single dose (600 mg) of CBD significantly reduced anxiety, cognitive impairment and discomfort during the public speaking test, which included a speech performance, and significantly decreased alert in their anticipatory speech. Interestingly, those, who received a placebo, presented higher anxiety, cognitive impairment, discomfort, and alert levels when compared with the control group as assessed with the Visual Analogue Mood Scale (VAMS). The Negative Self-Statement Scale (SSPS-N) scores evidenced significant increases during the testing of the placebo group that was almost abolished in the CBD group. Therefore, these results indicate that the use of CBD reduced the increase in anxiety induced by the SPST in individuals with SAD, thus leading to a similar response as the individuals without SAD [27]. A study conducted in a group of 47 adults with concerns of anxiety indicated that a dose of 25 mg of phytocannabinoids given per day was effective in decreasing the anxiety scores within the first month of treatment (79.2% participants) that remained decreased during the study duration [25]. Beneficial effects have been also noted in individuals with poor sleep quality, who after following CBD supplementation with a dose of 25 mg of Phyto-cannabinoids given per day, reported an improvement in sleep, within the first month (66.7% of participants) [25]. Additionally, a dose of 160 mg CBD a day has been shown to increase sleep time in those with insomnia as well as decrease nightly arousal [28].

Common beverages-tea and coffee

A number of clinical studies demonstrate beneficial health outcomes associated with tea and coffee intake that include improvements of certain metabolic markers including reduced blood pressure vascular function, and cholesterol levels, with possible favorable effects on blood glucose levels and inflammation. Epidemiological studies investigating the effect of regular consumption of common beverages, tea and coffee, have demonstrated potential in disease prevention.

Tea: Camellia Sinensis is a plant used in tea production, attributed to high bioactive content, especially polyphenols like catechins such as (-)-epigallocatechin-3-gallate (EGCG), which levels can be modified during processing. For example, the extent of oxidation determines the type of tea,

with black tea being more oxidized than green tea, and green tea more oxidized than oolong tea and white being the richest in antioxidants, as it is subjected to mild processing (air drying and crushing). In contrast, black tea is prepared from old leaves, followed by intense processing (drying, crushing and oxidizing) and has lower levels of natural antioxidants at expense of the highest caffeine and tannin content. Although the health benefits of tea consumption can depend on tea preparation (e.g., time and temperature of bereaving, and additions of other ingredients (e.g., lemon, honey, sugar, or milk)) [29,30] in general tea consumption is considered safe. Evidence obtained from high tea consumers obtained primarily from native populations of South Asian and South American countries has demonstrated individuals, who may be predisposed to diabetes, may significantly benefit from the use of tea ingestions, which may be available or produced locally. Estimates obtained from meta-analyses of observational studies examining associations between tea consumption and health outcomes indicate the largest reduction for diverse health outcomes, including reduced risks of total mortality, cardiac death, coronary artery disease, stroke, and type 2 diabetes for drinking two to three cups per day, with temperature not exceeding 55-60°C, as intake of hot tea was associated with esophageal and gastric cancer [29]. In addition, regular, tea consumption of ≥ 3 cups a day was associated with a lower type II diabetes risk, when compared with the lowest or non-tea drinkers [31]. Actually, for each cup (236.6 mL) increase in daily tea consumption (providing about 280 mg and 338 mg total flavonoids/d for black and green tea, respectively) was associated with an average 4% lower risk of cardiovascular mortality, a 2% lower risk of cardiovascular events, a 4% lower risk of stroke, and a 1.5% lower risk of all-cause mortality among the adults [32].

For example, Mauritian black and green teas-high in polyphenolics-have shown to have potent properties in a Mauritian population, who are predisposed to type two diabetes Interestingly, regular Mauritian tea intake has been linked with reduced CRP levels [33], as well as decreased fasting glucose, triglyceride levels and LDL/HDL cholesterol ratio with a significant rise in antioxidants in the normal healthy population [34]. Furthermore, results of a systematic review demonstrated that regular tea consumption of at least 3 cups/day was associated with a lower type II diabetes risk compared with the lowest tea intake or not drinking tea beverages at all [31]. Another meta-analysis investigating the health effects of tea reported that green tea consumption may exhibit beneficial effects on metabolic syndrome symptoms in the group of overweight or obese individuals with a BMI of 28 or higher, which have been attributed to protective effects against diabetes [35].

Interestingly, consumption of exclusively green tea (but not black tea), may reduce fasting blood glucose levels, compared to placebo or water. This effect was significant only in the individuals with a mean age of < 55 years old or in Asian-based studies. Interestingly, a similar trend for fasting blood glucose levels was observed for oolong tea however, the quality of evidence was considered very low [36]. Similar effects were observed following regular intake of green tea intake may improve lipid profile, observed as a significant reduction in the triglycerides, total cholesterol and LDL cholesterol levels, however with no effects on HDL cholesterol in both normal weight and overweight/obese individuals, when compared to control [37]. In particular, individuals with a BMI of 28 or higher (overweight or obese), tea consumption may provide beneficial effects on symptoms associated with the metabolic syndrome [12], including reduced incidence of diabetes and reduction in LDL cholesterol [35]. In particular, for hypertensive patients, regular tea intake over at least 3 months resulted in a reduction in systolic and diastolic blood pressure by about -3.53 and -0.99 mmHg, respectively; with more pronounced effects for green than black tea [12].

Additional reported benefits of tea include favorable effects on mental health and skin condition. For example, supplementation of 200-400 mg a day of L-theanine through green tea intake may help in the reduction of stress and anxiety in people exposed to stressful conditions [38]. In particular consumption of matcha-containing foods (4 g), such as tea or bar, significantly improved basic attention abilities and speed of the response to psychomotor stimuli over the period of time (~ 60 min), however with no significant changes in the mood [39]. In the case of skincare, intake of green tea supplements providing 540 mg (a dose equal to two cups of green tea) and 1080 mg of green tea catechins can significantly reduce skin erythema (reddening) after UV exposure in healthy individuals [40]. Daily supplementation of 1402 mg green tea catechins after 4 weeks increased photoprotection and decreased skin erythema in response to UV exposure in the group of females [41].

2.2.2. **Coffee:** Coffee is an example of a highly complex superfood, that can over 1000 bioactive compounds, such as caffeine, chlorogenic acids, and the diterpenes, cafestol and kahweol, which have been demonstrated a potentially therapeutic antioxidant, anti-inflammatory, as well as antifibrotic, or anticancer effects [42]. Nevertheless, certain procedures applied to coffee beans, including a degree of roasting, and preparation method including coffee grind setting and brew type; as well as the type of coffee beans (Arabica, Robusta) can influence of the biochemical composition of the final drink, what may influence on health effects reported in the studies [43]. Results of meta-analyses conducted on observational and interventional research consistently demonstrated that coffee consumption is associated with health benefits, rather than harm for a range of outcomes showing that intakes of three to four cups a day versus none, can lead to the largest reduction for the all-cause mortality, cardiovascular mortality and cardiovascular disease [43]. Antioxidants found in coffee,

such as chlorogenic acids (daily dose ranging from 787 mg or 407 mg) have been shown to bring benefit for cardiovascular health, demonstrated as increased cholesteryl esters, followed by a reduction in oxysterols and free fatty acids levels after daily consumption of a coffee beverage (400 ml a day) of chlorogenic acids after 8 weeks among apparently healthy adults [44]. Similarly, intake of green coffee either as extract (from 180 to 376 mg) in a capsule or as a decaffeinated coffee drink (510.6 mg) rich in chlorogenic acid improved the metabolic syndrome symptoms observed as reduced waist circumference, triglyceride levels HDL cholesterol levels, systolic and diastolic blood pressure; and fasting blood glucose levels [45]. Interestingly, the intake of coffee with added cow's milk has beneficial effects on post-exercise muscle recovery and glycogen levels, after cycling sessions in male athletes. The results suggest that the addition of coffee to a beverage with adequate amounts of carbohydrates increased muscle glycogen re-synthesis and the glycemic and insulinemic response during the 4h recovery after endurance training [46]. Also, preloading with decaffeinated coffee (140 ml) with added milk (50 ml of low fat cow's milk) and sugar (7.5 g) led to a blunted postprandial glycaemic response after consuming a high-glycemic index meal (GI 88) consisting of puffed rice cereal (30 g), glucose powder (10 g) and rice milk (150 ml) [47]. Finally, similarly to tea, also coffee intake has been associated with better mental health conditions, with mental analyses showing that drinking 400 ml of coffee a day may be protective against depression [48].

Fermented products

The findings of several epidemiological studies have shown that the consumption of fermented foods might bring benefits for diabetes management and other symptoms associated with metabolic syndrome. These effects were observed predominantly for fermented milk-based fermented food, with a lesser number of studies showing similar benefits for regular intake of other fermented foods, such as sauerkraut, kimchi, and miso paste [49]. The reason for that is related to the fact that lactic bacteria are widely used in fermented dairy foods, either as starter cultures or as naturally occurring members of the raw material.

Algae and marine plants

Marine algae, including Wakame (Undaria), Konbu (Laminaria), Nori/Gim (Porphyra), and Hijiki (Hizikia) [50] are considered a high-quality source of polysaccharides, polyunsaturated fatty acids, vitamins (A, B1, B2, B9, B12, C, D, E, and K), essential minerals (calcium, iron, iodine, magnesium, phosphorus, potassium, zinc, copper, manganese, selenium, and fluoride), and other bioactive metabolites with antioxidant and anti-inflammatory properties [51]. Phytocomplex obtained from seaweeds, Fucus vesiculosus and Ascophyllum nodosum, with commercial name Gdue™, given to overweight or obese adults, after 6 months significantly decreased waist circumference, as well as reduced both glucose and insulin levels, followed by the further improvements in the insulin resistance [52]. Similarly, overweight and obese individuals with a median age of 55 years old, who received 2g or 4 g dose of green seaweed Ulvacean containing a sulfated polysaccharide (ulvans) known as "xylorhamnoglucuronan", after 6 weeks had significantly improved lipid profile, observed as reduction in non-HDL (high-density lipoprotein) cholesterol, as well as in the atherogenic index, an indicative of triglycerides and HDL cholesterol (biomarker for dyslipidemia) and 2 h insulin [53]. In addition, drinking a freshwater algae infusion, known as ProAlgaZyme, four times a day for a total of 10 weeks, had significantly reduced weight, body fat, total cholesterol, LDL-cholesterol, triglycerides, CRP and fasting blood glucose levels in overweight and obese adults aged between 25 and 60 years old [54]. A body weight control program incorporating exercise and nutrition education, as well as additional supplementation with 20 g of Laminaria japonica per day, contributed to decreasing blood cholesterol levels, as well as lower body weight, fat mass, waist–hip ratio, and body mass index and improved the quality of life and physical functioning [55]. Intake of wholemeal bread enriched with algae, Ascophyllum nodosum (4% per 400 g wholemeal loaf), as part of a meal in the group of overweight adult males led to a significant reduction (16.4%) in energy intake during meal 4 h later, as well as a total energy intake which after 24 h was approx.. 500 kcal lower when compared to individuals consuming a control bread [56].

Supplementation of 2 g of dried spirulina powder for 2 months lowered fasting blood glucose and postprandial blood glucose levels in patients with type 2 diabetes [57]. Similarly, adding algae to daily diet as part of the meal may also contribute to improved long-term glycemic control demonstrated as reduced glycosylated hemoglobin (HbA_{1c}) level. Consequently, the co-consumption of 200 g portion of white rice together with 4g of dried wakame Undaria pinnatifida, in the representative group of healthy adults significantly reduced blood glucose and insulin levels after 30 min from the meal, when compared with eating rice alone. Moreover, the incremental areas under the curves for glucose and insulin were lower when wakame seaweed was included [58]. Similarly, the addition of 70 g of Mekabu, sporophylls of Wakame, to meals, that included 200 g white rice, 50 g boiled soybeans, 60 g potatoes, or 40 g broccoli can significantly lower postprandial glucose measured 30 min after consumption [59]. Furthermore, daily intake of Arthrospira extract, known as "Spirulysat®" after 12 weeks, significantly decreased oxidative damage, determined by the urinary levels of individuals with metabolic syndrome, aged between 18 and 65 years of age with metabolic syndrome [60]. Additionally, supplementation with a 1.5 g a day of algae Laminaria japonica and probiotic strain, Lactobacillus brevis BJ20 after 4 weeks decreased serum Gamma-Glutamyl Transferase (GGT) levels (GGT < 132 U/L) and improved an antioxidant activity, characterized

by increased catalase (CAT) and SOD levels in adults with reported high GGT [61].

Finally, algae has been shown to be beneficial for gut health. Supplementation of dried Laminaria japonica powder known as Harudori-kombu, with a 2 g a day dose for 6 weeks, improved gastrointestinal health, demonstrated by reduced adverse gastrointestinal symptoms including decreased passage of stools [62]. Interestingly, intake of 375 mg a day of dried Whole Cell Algae Fermentate of Euglena gracilis after 4 weeks induced favourable changes in microbiota composition characterized by increased relative abundance of Bacteroidetes and smaller ratio of Firmicutes to Bacteroidetes (F/B) in the group of adults mild gastrointestinal issues [63]. Furthermore, combining alage with multistrain probiotic preparation, like this combining three strains of Lactobacillus (*L. acidophilus, L. plantarum, and L. rhamnosus*), and one strain of Streptococcus (*S. thermophilus*) in Korean adults after 4 weeks, lead to changes in the gut microbiota composition characterized in the increase of four (out of the seven) LAB species (B. brevis, B. lactis, L. plantarum, and L. rhamnosus), however with no changes in the placebo group [64].

Stevia and fermented plants

Stevia plants, similar to other fruits and vegetables are source of bioactives with characteristic sweet taste and low-calorie content, which are often incorporated as low-calorie natural [65] in various foods.

Stevia rebaudiana, a plant rich in steviol gylcosides (E960), in particular, Stevioside and Rebaudioside A, is known as natural low-calorie sweetener. Stevia is widely used as a sweetener in foods, drinks and bakery products due to its stability at elevated temperatures [65] and high sweeteners power ranging from 200 to 300 times of sucrose. Steviol gylcosides, having a zero glycemic index have proposed potential therapeutic applications attributed to phytochemical compounds, such as flavonoids and fatty acids, that have been attributed health-promoting effects, such as increasing insulin production, as well as antibacterial, antioxidant and immune-modulating properties [66]. Similarly, intake of naturally derived steviol glycoside (Stevioside) in daily doses ranging between 200-1500 mg can reduce fasting blood glucose. Therefore, using plant-derived sweeteners, instead of traditional sugar (sucrose) may be beneficial for individuals with certain metabolic disturbances. For example, daily consumption of Stevia between 200-1500 mg of steviol glycoside (Stevioside) years demonstrated a potential beneficial effect on weight favoring a trend towards lower BMI as well as markedly decreased metabolic biomarkers including total cholesterol and High-Density Lipoprotein Cholesterol (HDL-C) [67].

Fermented foods

Regular intake of fermented foods, of both animal and plant origin, has been shown to bring favorable effects on glycemic control. Individuals aged between 18 and 65 years old, who regularly consumed a 180ml portion of kefir had significantly decreased fasting insulin and inflammatory markers (TNF-α, IFN-γ) reported after 12 weeks [68]. The systematic review and meta-analysis of randomized controlled trials evaluating the effects of kefir drink on glycemic control indicated that regular kefir intake for periods ranging between 15 and 84 days can lead to a significant reduction in the fasting blood glucose and insulin levels; with additional potential benefits linked to decreased hemoglobin A1c (HbA1c) [69]. Similar beneficial effects were observed for the intake of traditional Korean foods, such as fermented vegetables have been shown to be effective in reducing glycated haemoglobin levels in the group of hypertensive and type 2 diabetic patients [70]. This effect was in particularly prominent for kimchi (fresh fermented cabbage) which lowered insulin resistance and increased insulin sensitivity among pre-diabetics individuals [71]. Interestingly, certain fruit and vegetables subjected to fermentation may also be considered a rich source of polyols sugar alcohol), such as erythritol, mannitol, and xylitol [72] that are similar to steviol glycosides are used as low-calorie sweeteners, as well as flavor enhancers, cooling agents, humectants, and thickeners during food production. Among all sugar alcohols, xylitol is the sweetest polyol with low-calorie content (2.4 kcal/g), which can be metabolized by colon bacteria into bioactive compounds with potential metabolic effects, promoting the release of gut hormones and satiety [73]. Interestingly, xylitol brings benefits for dental health characterized as reduced bacterial load and cavities [74].

Furthermore, plant-derived sweeteners can help with metabolic disturbances. Acute consumption of beverages sweetened with sugar alcohols, compared to drinks sweetened with sucrose with varying energy contents between 103 and 215 kcal, resulted in greater production of a peptide hormone involved in enhancing the secretion of insulin GLP-1 (glucagon-like peptide 1) [75]. This has been observed following the intake of erythritol and xylitol, where there was a noticeable increase in both GLP-1 and Cholecystokinin (CCK) release, leading to greater satiety [76] and delayed gastric emptying [72]. In addition, intake of various doses of xylitol (7, 17 or 35 g) when compared to tap water on 4 separate days, lead to a dose-dependent stimulation of Cholecystokinin (CCK), active glucagon-like peptide-1 (aGLP-1), Peptide Tyrosine-Tyrosine (PYY)-release, and decelerated gastric emptying rates in a dose-dependent manner, observed as an increase in glucose and insulin levels and decreasing in gastric emptying rates [73]. Interestingly, a long-term intake of xylitol and erythritol of either 8 g of xylitol or 12 g of erythritol three times a day for 5 to 7 weeks does not affect glucose homeostasis in individuals with obesity [74]. Similarly, the administration of xylitol (50 g) or erythritol (75 g) in both lean and obese adults has no significant effect on insulin response [72]. Intake of xylitol resulted in increased

production of GLP-1 and CCK, which has been attributed to improvement in insulin sensitivity and decreased secretion of glucagon in both lean and obese individuals [77].

Additional improvements resulting from regular intake of fermented foods are also noted for gut health, particularly milk-based foods. For example, consumption of a 180 ml serving of kefir after 12 weeks led to favorable changes in the gut microbiota, observed as a significant increase in the relative abundance of Actinobacteria [68]. In addition, a pilot study demonstrated that the intake of a 500 ml serving of kefir drink in patients with functional constipation after 4 weeks improved digestive functions, characterized by increased stool frequency and improved stool consistency, as well as decreased laxative consumption. Furthermore, kefir drink accelerated the colonic transit thereby leading to improved bowel satisfaction scores among the treatment group [78]. Consumption of milk-containing L. acidophilus by individuals with lactose intolerance was able to reduce gastrointestinal symptoms when compared to the intake of regular milk [79]. Also, an intake of 400 ml serving of no fermented reduced fat (2%) milk containing L. bulgaricus containing significantly improved symptoms of lactose maldigestion [80]. It must be mentioned that regular consumption of kefir, in particular breakfast with high (white bread with raspberry jam) GI has been shown to prevent the rapid increase in appetite and food intake resulting from postprandial responses among young adult females aged between 21 and 24 years old. Interestingly, in the case of a low-GI meal, addition of kefir had no advantages over full-fat milk [81]. Furthermore, a regular consumption of kimchi decreased body mass, BMI and waist perimeters in the prediabetes patients [71].

Interestingly, fermented foods may also aid recovery after intensive edurance training. In that case, kefir consumption among apparently helathy adults aged between18 to 24 years old, who performed a 15 week long endurance training programme following post-exercise intake of 454 g serving of kefir providing 10^9-10^{10} CFU of lactic acid bacteria and 10^7-10^8 CFU of yeasts and CFU, had improved the 1.5-mile (2.41 km) times of running, as well as reduced inflammatory markers in blood (C-reactive protein level), thereby suggesting kefir as convenient and healthy recovery beverage for athletes which should be considered in a sport nutrition plan [82].

Fermented foods, esspecially those containg probiotics, like fermented milk (2 ml/kg a day) after 90 days resulted in the improvements in the cognitive deficits, characterized by decrease in inflammation and oxidative stress in patients with Alzheimer and Dementia, who exhibiting cognitive deficit [83]. Similarly, intake of yogurt containing a bacteria cultures *Lactobacillus acidophilus* LA5 and *Bifidobacterium lactis* BB12 after 6 weeks, lead to reductions of depression, anxiety and stress symptoms in adults [84]. Interestingly, intake of 800 mg dose of fermentate of *Lactobacillus plantarum* C29 and soybean in the form of dietary supplement after 12 weeks improved cognitive function in individuals with Mild Cognitive Impairment [85].

Conclusion

Functional foods, whenever obtained from natural sources of subjected to certain processing and enrichments may contribute to the achievement of specific health objectives linked to prevention of certain diseases and management of chronic conditions.

Superfoods, being a part of daily diet, due to high in nutritional content with great biological availability can promote overall health and reduce risk of chronic disease.

The most commonly found nutrients with attributed health-promoting activities include omega-3 fatty acids, vitamins (vitamins A, C and E), minerals (selenium, zinc), probiotics, antioxidants (polyphenols, anthocyanidins, flavonoids, β-carotene, lycopene) and dietary fibres.

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How to cite this article: Jurek JM. Health Benefits of Functional Foods. 2022 Nov 10; 3(11): 1307-1316. doi: 10.37871/jbres1598, Article ID: JBRES1598, Available at: https://www.jelsciences.com/articles/jbres1598.pdf