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Current Perspective at Specific Issues in Nutrition I

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Nilüfer TEK

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PREFACE

Nutrition forms the basis of health in every period of life. Irritable bowel syndrome is a gastrointestinal disorder that affects the large intestine, causing changes in the digestive system such as diarrhea, gas and constipation, and painful cramps. Nutrition plays a role in the occurrence of IBS symptoms. Individual nutrition approach is effective and important in reducing symptoms and improving quality of life.

Foods that, in addition to their basic nutritional properties, have properties that positively affect health are defined as "functional foods". However, there is some confusion about which foods are functional. In this book, the effects of some functional foods on health are examined. Food labels is important, which enable the consumer to establish a self-control mechanism, not only help to make the right food choices, but also contribute to the development of consumer behaviors related to adequate and balanced nutrition.

Editor

Prof. Dr. Nilüfer TEK

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CHAPTER I

Nutritional Approaches in Irritable Bowel Syndrome

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Introduction

Irritable bowel syndrome is one of the most common gastro-intestinal diseases. Its incidence is gradually increasing in the world and in Turkey. The causes of the disease, which is seen especially in women and young population, are not yet known exactly. The prevalence of the disease is approximately 10% in the world. It is roughly 7% in the Middle East and Southeast Asia, 11.8–14.0% in North America, Northern Europe, and Australia, and 15.0–21.0% in South America, Southern Europe, and Africa (Lovell & Ford, 2012). In a study including 32 cities in Türkiye, the prevalence of IBS was found to be 33.5% (Özden & et al., 2006).

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Symptoms of the disease usually occur in the 30-50 age range. The prevalence of IBS slightly decreases with age and may also occur in old age (Houghton & et al., 2016). The ratio is reported to be 2/1-3/1, with a higher occurrence among women worldwide and in Türkiye (Karaman, Türkay & Yönem, 2003).

Significantly increased monthly (30-day) prescriptions due to irritable bowel syndrome, average annual hospitalisations, emergency room visits and outpatient services have a negative impact on health expenditure (Buono & et al., 2017). In addition, the greater activity impairment of individuals with IBS significantly affects the ability to work. This disease, which is very common, causes a significant economic burden in this way (Talley& et al., 1995).

The pathophysiology of irritable bowel syndrome includes altered gas accumulation, increased GI fermentation, altered GI motility, dysbiosis in the intestinal microbiota, and decreased quantity and diversity of *bifidobacteria* in the lumen, despite the fact that the origin of the condition is still unknown (Drossman, 2016). Gastro-intestinal endocrine cells regulate various functions of the intestine, including sensation, motility and secretion. The density of intestinal endocrine cells is usually reduced in patients. This reduction is due to a decrease in the self-renewal and proliferation of intestinal stem cells (Cheng & Leblond, 1974). This alteration of stem cells is influenced by environmental factors such as genetic predisposition, chronic stress, infection and nutrition (El-Salhy, 2012). Possible factors that may have effects on the pathophysiology of IBS are shown in *Figure 1.* (El-Salhy, 2015).

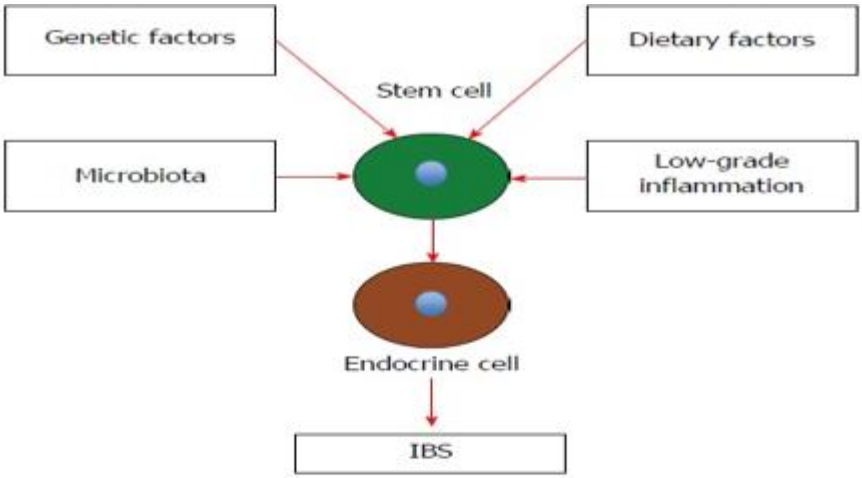

Figure 1. Factors involved in the pathophysiology of IBS

The treatment of this disease, which negatively affects the quality of life of the individual, is planned specifically for the patient. Medical nutrition therapy is also an important process that improves the patient's quality of life and reduces the cost of treatment. In this book chapter, Irritable Bowel Syndrome and current nutritional treatment methods are included.

Irritable Bowel Syndrome

Chronic functional bowel disease known as irritable bowel syndrome, better known as IBS, is defined by pain or discomfort in the abdomen and changes in the frequency or shape of stools (Lacy & et al., 2016). There are different subtypes in Irritable Bowel Syndrome and these subtypes are determined by stool consistency. Bristol stool scale form is used to evaluate stool consistency. For the stool types shown in Figure 2, stool types 1 and 2 indicate constipation, types 3 and 4 indicate normal stools and types 5 and 7 indicate diarrhoea (Lewis & Heaton, 1997).

Subtypes of Irritable Bowel Syndrome

In Irritable Bowel Syndrome, there are four subtypes according to stool shape. In constipation-dominant IBS (IBS-C), hard stools (type 1-2) are present in more than 25% of stools and watery stools (type 6-7) in less than 25% of stools. In diarrhoea-predominant IBS (IBS-D), watery stools (type 6-7) are present in more than 25% of stools and hard stools in less than 25%. If both hard and watery stools are present in more than 25% of the stools, it is defined as mixed type IBS (IBS-M). If both hard and watery stools are present in less than 25% of defecations, it is called non-specific IBS (IBS-U) (Spiller & Thompson, 2010). Figure 2 shows the faecal forms.

Separately hard pieces		1
Hard pieces in the form of sausage		2
Sausage-shaped, fractures on the surface		3
Sausage or snake shaped, smooth or soft		4
Large pieces with defined edges		5
Irregular particles with irregular edges		6
Watery, no hard pieces		7

Figure 2. Bristol stool scale form

Symptoms and diagnosis of Irritable Bowel Syndrome

The main symptoms of the disease include chronic abdominal pain and altered bowel movements (Lacy& et al., 2016). At the same time, the incidence of some stress-related diseases was found to be significantly higher in patients than in non-patients. Various gastro-intestinal diseases such as dyspepsia, gastroesophageal reflux, non-cardiac chest pain and non-gastro-intestinal diseases such as anxiety, depression, fibromyalgia, chronic pelvic pain, chronic fatigue have also been associated with IBS (Quigley& et al., 2012). Mood disorders and non-gastro-intestinal pain syndromes such as fibromyalgia and migraine are seen in two thirds of patients with IBS (Sayuk & Gyawali, 2015).

Since objective examination, laboratory and imaging methods are not available for the diagnosis of the disease, the diagnosis of the disease is based on symptoms. ROMA and Manning criteria are used in clinics to standardise the diagnosis (Kasap &et all., 2011). IBS is categorized as constipation-dominant IBS (IBS-C), diarrhea-dominant IBS (IBS-D), varied bowel movements (IBS-M), and unclassifiable (IBS-U) based on with the most recent diagnostic criteria (ROMA IV criteria) (Drossman, 2016). The diagnosis of IBS is made when abdominal pain or discomfort occurs at least 1 day a week in the last 3 months and is accompanied by at least two of the three findings (alleviation of symptoms with defecation, onset with change in the frequency of defecation, onset with change in the shape and appearance of the stool). Symptoms must have started at least 6 months before the patient presents. ROMA IV criteria are summarised in *Table 1* (Schmulson & Drossman, 2017).

Table 1. ROMA IV criteria for the diagnosis of IBS

ROMA IV criteria
1.Recurrent abdominal pain or abdominal discomfort (at least 1 day per week in the last 3 months)*
2. At least 2 or more of the following 3 findings accompanying abdominal pain: a. Relief of symptoms with defecation b. Starting with a modification in the frequency of bowel movements c. Starting with a modification in the form and appearance of feces

* Symptoms must have started 6 months or more before the patient presents

The treatment phase of disease management is the most difficult process. In practice, treatment is mainly directed at the individual's symptoms and should be progressed step by step according to the severity of the patient's symptoms (Akyuz, 2016).

First of all, after the diagnosis of the disease, the physician should approach the patient with empathy to relieve the patient's concerns. There are many treatment methods such as medical treatment, nutritional therapy, psychopharmacological treatment, physical and behavioural treatment (Trinkley & Nahata, 2011).

Medical Treatment and Psychopharmacological Treatment of Irritable Bowel Syndrome

When dietary and lifestyle recommendations are insufficient to improve symptoms, medical treatment is applied to the symptoms of individuals (C. J. Black & Ford, 2021). For this purpose, motility and pain-specific drugs such as enteric-active, pulp, prokinetics are used (Tanaka, & et al., 2011). Antispasmodic drugs used in the first stage are used to provide positive improvements in peristalsis and spasm by reducing symptoms such as pain and bloating. As recommended in the National Institute for Health and Clinical Excellence guidelines, loperamide with antidiarrhoeal effect is among the commonly used drugs in patients with diarrhoea-dominant IBS (Hookway, & et al., 2015). Among antibiotics, Rifaximin is predominantly effective in patients with diarrhoea-predominant IBS and is used after antidiarrhoeal agents (Khan & Chang, 2010). Both osmotic and stimulant laxatives are used in IBS patients with predominant constipation (Ford & Suares, 2011). Caution should be exercised when using lactulose because it causes bloating. It is recommended to adjust the dose of laxatives according to the clinical response. Neuromodulators such as tricyclic antidepressants (TCAs) or serotonin reuptake inhibitors (SSRIs) are used in the second phase. (Hookway & et al., 2015). Tricyclic antidepressants relieve symptoms such as abdominal pain and diarrhoea and improve slow colonic transit times (Hadjivasilis & et al., 2019).

Physical Activity in Irritable Bowel Syndrome

Physical activity may improve intestinal gas clearance by accelerating gastro-intestinal transit in individuals with bloating. In addition, microbial diversity increases through the gut-brain axis and symptoms decrease (C. J. Black & Ford, 2021). It is also reported that the effects of exercise on IBS are provided by enhancing neurogenerative, neuroadaptive and neuroprotective processes in the central nervous system (Fani, & et al., 2019). In a study evaluating the effects of physical activity on IBS, it was reported that there was a significant decrease in IBS symptom severity scores in individuals in the physical activity group compared to the control group (Johann, & et al., 2011). In a meta-analysis study (683 IBS patients) in which the effects of different types of exercise (yoga, walking/aerobic, mountaineering) on IBS were evaluated, it was reported that the effects of exercise on the symptoms and quality of life of individuals were positive (Zhou & et al., 2019).

Behavioural Treatment in Irritable Bowel Syndrome

It is important to adopt certain behavioural self-care skills (self-monitoring, problem solving, education, negative mood management, managing somatic conditions such as pain) in chronic diseases. These skills, which form the basis of the psychological treatment approach, are called cognitive behaviour therapy (Lackner & et al., 2008). Treatments such as cognitive behavioural therapies, hypnotherapy and psychotherapy reduce the symptoms of the disease through their effects on the gut-brain axis (Hadjivasilis & et al., 2019). In addition to the positive effects, these treatment methods are both time-consuming and costly (Tan, Yildirim, & Guldal, 2014).

Nutrition and IBS relation

In individuals with Irritable Bowel Syndrome, 28% reported that their symptoms increased/worsened within 15 minutes and 93% within 3 hours after food consumption (Simrén & et al., 2001). In relation to this, it is reported that dietary components are involved in symptom formation in 50-84% of patients with IBS (Böhn, & et al., 2013; Quigley, 2014). Therefore, the focus is on certain nutritional components (pulp, lactose) for treatment (Böhn & et al., 2013).

The prevalence of the disease is 5-9% in Asian countries and 10-20% in Western countries, suggesting that this difference may be related to the nutritional models of the countries (Christopher J Black & Ford, 2020). The Western dietary pattern is rich in fats and meat protein and low in carbohydrates and fibre, whereas the Asian diet is rich in carbohydrates and fibre and low in fats (El-Salhy, Patcharatrakul, & Gonlachanvit, 2021). In a large cohort study, patients reported that a Western dietary pattern, especially high in sugar and fat, induced IBS symptoms (Buscail & et al., 2017). It was reported that 84% of the patients reported that especially foods containing fermentable carbohydrates and fats caused symptoms (Böhn & et al., 2013). However, many IBS patients report that milk and dairy products, wheat products, caffeine, vegetables such as cabbage, onions, peas, beans, hot spices, fried foods and smoked products are common triggers for their symptoms (Simrén & et al., 2001). Since milk and dairy products contain lactose, they cause symptoms and IBS patients turn to alternative herbal drinks such as soya, rice and oat milk (El-Salhy & et al., 2021). A large proportion of patients with Irritable Bowel Syndrome associate at least one food with their symptoms and two thirds of patients report restricting their diet (Jamieson, Fletcher & Schneider, 2007).

Nutrients associated with symptoms also significantly affect the quality of life of individuals. (Cuomo & et al., 2014). Decreased quality of life leads to increased use of health services, significant reduction in daily activities and loss of workforce (Hungin, & et al., 2005). Therefore, nutrition that plays a role in the occurrence of IBS symptoms and what kind of nutritional therapy should be used to control symptoms have been the subject of many researches (El-Salhy & Gundersen, 2015). It has been reported that intestinal distension and microbiota are effective as the main ways of food effects on disease symptoms (P. A. Hayes, Fraher & Quigley, 2014).

The relationship between nutrients and IBS symptoms is shown in *Figure 3.* Primary effects of nutrients include osmotic, chemical, mechanical, neuroendocrine, pro-, pre- and postbiotic causes, while secondary effects include fermentation by-products, changes in intraluminal pH and effects on the microbiome (Dolan, Chey & Eswaran, 2018).

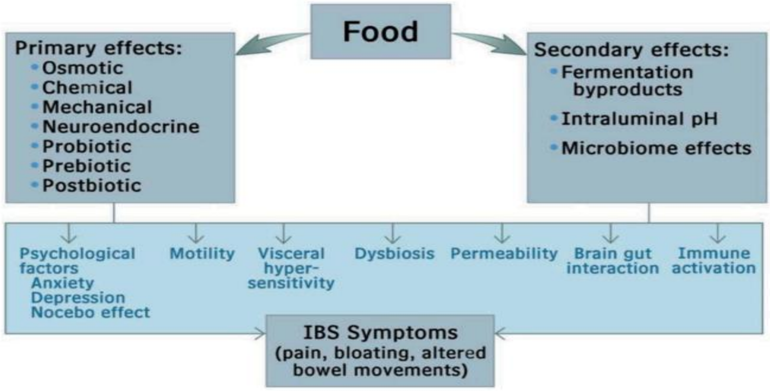

Figure 3. Association between nutrients and IBS symptoms

Nutrition Approaches in Irritable Bowel Syndrome

Reducing symptoms and enhancing the quality of life for those with Irritable Bowel Syndrome are the goals of dietary treatment. In this part of the book, current nutritional therapies are described under the titles of traditional dietary recommendations, low FODMAP diet and gluten-free diet, explaining their positive and negative aspects.

Traditional Dietary Recommendations

There are different approaches to medical nutrition therapy for Irritable Bowel Syndrome. Firstly, traditional dietary therapy is recommended by the British Dietetic Association and the National Institute for Health and Clinical Excellence (Hookway & et al., 2015). The individual's lifestyle and dietary habits are assessed by the health professional. This assessment includes the regularity of meals, adequate fibre intake, consumption of alcohol and caffeinated beverages, amount of fat intake and evaluation of spices that may contribute to symptoms. Recommendations also include ensuring adequate hydration and regular physical activity (Cozma-Petruţ, Loghin, Miere, & Dumitraşcu, 2017). These recommendations are the result of studies on eating habits, caffeine, alcohol, spices, pulp and fat consumption.

Eating habits;

More irregular eating habits have been reported in IBS patients compared to healthy individuals (Guo & et al., 2015). It has been suggested that irregular eating may affect colonic motility and thus contribute to IBS symptoms. It is observed that symptoms increase by 30% in individuals with irritable bowel syndrome when they skip meals. It is also reported that the risk of disease is higher in individuals who do not regularly consume three main meals during the day (Karaman & et al., 2003). Eating habits and chewing adequacy are also associated with the risk of IBS. In a related study, the risk of IBS was found to be significantly higher in those with five tooth loss compared to those with one tooth loss (Khayyatzadeh & et al., 2018). Patients are therefore advised to establish a regular eating schedule (appropriate breakfast, lunch and dinner times) and not to skip meals or eat late at night. It is also recommended that individuals avoid eating large amounts of food at meals, take enough time to eat and chew food thoroughly (Cozma-Petruţ & et al.,2017).

Table 4. Table 1 Food sources of FODMAPs (where FODMAPs are problematic based on standard serving size) and suitable alternatives

FODMAP	**Excess fructose)**	**Lactose**	**Oligosaccharides (fructans and/or galactans)**	**Polyols**
Problem high FODMAP food source	Fruits: apples, pears, nashi pears, clingstone peaches, mango, sugar snap peas, watermelon, tinned fruit in natural juice	Milk: cow, goat and sheep (regular & low-fat), Ice cream	Vegetables: artichokes, asparagus, beetroot, Brussels sprout, broccoli, cabbage, fennel, garlic, leeks, okra, onions, peas, shallots	
	Honey	Yoghurt (regular & low-fat)	Cereals: wheat & rye when eaten in large amounts (e.g. bread, pasta, couscous, crackers, biscuits)	Fruits: apples, apricots, cherries, longon, lychee, nashi pears, nectarine, pears, peaches, plums, prunes, watermelon
	Sweeteners: fructose, high fructose corn syrup	Cheeses: soft & fresh (e.g. ricotta, cottage)	Legumes: chickpeas, lentils, red kidney beans, baked beans	Vegetables: avocado, cauliflower, mushrooms, snow peas
	Large total fructose dose: concentrated fruit sources; large serves of fruit, dried fruit, fruit juice		Fruits: watermelon, custard apple, white peaches, rambutan, persimmon	Sweeteners: sorbitol(420), mannitol(421), xylitol(967), maltitol (965), isomalt (953) & others ending in '-ol'
Suitable alternative low-FODMAP food source	Fruit: banana, blueberry, carambola, durian, grapefruit, grape, honeydew melon, kiwifruit, lemon, lime, mandarin, orange, passionfruit, paw paw, raspberry, rockmelon, strawberry, tangelo.	Milk: lactose-free, rice milk Cheese: 'hard' cheeses including brie, camembert Yoghurt: lactose-free Ice cream substitutes: gelati, sorbet Butter	Vegetables: bamboo shoots, bok choy, carrot, celery, capsicum, choko, choy sum, corn, eggplant, green beans, lettuce, chives, parsnip, pumpkin, silverbeet, spring onion (green only), tomato	Fruits: banana, blueberry, carambola, durian, grapefruit, grape, honeydew melon, kiwifruit, lemon, lime, mandarin, orange, passionfruit, paw paw, raspberry, rockmelon
	Honey substitutes: maple syrup, golden syrup		Onion/garlic substitutes: garlic-infused oil Cereals: gluten-free & spelt bread/cereal products	Sweeteners: sugar (sucrose), glucose, other artificial sweeteners not ending in 'ol'
	Sweeteners: any except polyols			

Table 5. Low FODMAP diet phases

1. Elimination phase	Foods high in FODMAPs are cut off of the diet for two to eight weeks.
2. Reintroduction phase	Small portions of FODMAP foods are introduced into the diet and symptoms are noted to repeat.
3. Maintenance phase	The diet is adapted according to the tolerance level of the individual.

Some difficulties may develop for the patient and dietitian during the implementation of a low FODMAP diet. The most important of these difficulties is the complexity of the content of the diet and teaching it to the patient and nutrient deficiencies that may occur. However, the use of alternative foods affects the applicability of the diet by affecting kitchen expenses (Hill, Muir & Gibson, 2017). At the same time, patients' time for menu planning and shopping for a low FODMAP diet are among the reasons that reduce adherence (Werlang, Palmer & Lacy, 2019).

The fact that the duration of the first interview in which medical nutrition therapy will be explained to the patient is approximately one hour makes it difficult to perform it in an intensive primary health care setting. However, it is important to provide complete nutrition education in order to better ensure the individual's compliance with nutrition therapy. In a study in which the content of the low FODMAP diet was given to patients as group education, it was observed that 82% of the participants improved their symptoms (Kinrade, 2014). In a study in which low FODMAP diet was explained to patients as one-to-one and group trainings, disease symptoms decreased significantly in both groups and no difference was found between the groups. The results of the study show that group trainings can also be performed by clinicians and clinically beneficial responses are observed (Whigham & et al., 2015). Patient education, which is the basic step in the treatment of the disease, should start to be given by the physician as soon as the patient is diagnosed. The patient should be explained that the disease is a chronic condition with uncertain treatment and that the treatment is based on the improvement of symptoms. It has been shown that IBS patients need fewer hospital visits in a process followed in this way (O'Sullivan & et al., 2000).

Risks of a low-FODMAP diet

In the common results of the studies, the risks of low FODMAP diet therapy include altered gastro-intestinal microbiota, pulp intake, eating disorders, and nutrient deficiencies.

Altered gastro-intestinal microbiota

Since fructans and galactans have prebiotic properties, their removal from the diet will cause a change in the composition of the intestinal microbiota and a decrease in beneficial bacteria (Molina-Infante & et al., 2016). Supporting this, studies have shown a decrease in the relative abundance of Bifidobacterium bacteria in faeces within 3-4 weeks in individuals on a low FODMAP diet (Halmos & et al., 2015, Staudacher & et al., 2012).

Dietary fibre intake

It is recommended that the total amount of fibre (ingested and supplemented) in the diet of patients with Irritable Bowel Syndrome should be 20-30 grams per day and this amount should be reached gradually (Cozma-Petruţ & et al., 2017). Dietary fibre is found in high FODMAP foods such as wheat, rye and legumes and therefore the amount of fibre is reduced in a low FODMAP diet (Halmos &et al., 2014). The use of oat and rice bran, which have high soluble fibre content that can be fermented less in a low FODMAP diet, is recommended (Dugum, Barco & Garg, 2016). The association of low FODMAP diet with long-term risks of diseases such as cardiovascular diseases and colorectal cancer, especially due to the restriction of insoluble fibre, needs to be explained (Park & et al., 2005; Threapleton & et al., 2013).

Eating disorders

Anxiety and gastro-intestinal symptoms are reported to cause eating behaviour disorders. Individuals' caution in food selection, menu planning, food purchasing, preparation and consumption during nutritional treatments and their exaggerated beliefs that the inclusion or elimination of certain foods in the diet may affect the prevention or cure of the disease are reported as the cause of eating disorders (Satherley, Howard & Higgs, 2015). The American Gastroenterological Association recommends that health professionals ask individuals about their nutritional status, weight loss and laxative use in every patient interview to prevent eating disorders (Chey & et al.,2022).

Nutrient deficiencies

Elimination diets are generally associated with inadequate calorie intake, weight loss and nutrient deficiencies (Bellini & Rossi, 2018). Low FODMAP diets especially risk inadequate carbohydrate, dietary fibre, B vitamins, vitamin D and calcium intake in parallel with restricted food groups (Staudacher & et al., 2017). With a low FODMAP diet, you might not be getting enough naturally occurring antioxidants like phenolic acids and anthocyanins found in fruits or flavonoids, carotenoids, and vitamin C found in some high FODMAP foods (including cauliflower, onion, and garlic) (Catassi & et al., 2017). Studies support that a low FODMAP diet is effective on symptoms (McIntosh & et al., 2017; Staudacher & et al., 2012). However, *Table 6* summarises the limitations and risks of this dietary therapy (Molina-Infante & et al., 2016). Based on all studies, the American Gastroenterological Association has established a 9-stage nutritional therapy that should be considered in the treatment of IBS. In the treatment protocol, a nutrition programme is recommended primarily for the symptoms of the individual. At this stage, it is recommended to switch to a low FODMAP diet when adequate improvements are not achieved with conventional nutrition therapy (Chey & et al., 2022).

Table 6. Putative limitations of a low FODMAP diet for IBS

Limitations related to the low FODMAP concept
High level of restriction due to carbohydrate additive effects
Avoidance of most wheat sources may lead to reduced gluten intake in the low FODMAP diet
The mechanisms by which FODMAPs induce lethargy and other extradigestive manifestations remain to be elucidated
The reintroduction process is yet to be clarified and may be difficult due to carbohydrate additive effects
Limitations related to reported literatüre
Lack of medium- and long-term results of efficacy, the majority not beyond 6 weeks
Concerns with different placebo and comparator group (placebo, standard diet)
Blinding is complex and may not reflect a "real life" scenario
Other therapeutic interventions (standard dietary advice for IBS, gut-directed hypnotherapy, probiotics) have been recently shown not inferior to a low FODMAP diet for IBS
Limitations related to the safety of the diet
Impact on richness and diversity of gut microbiota (fructans and GOS are prebiotics)
Nutritional inadequacy, mostly related to dairy restriction
Potential increased cardiovascular diseases or colorectal cancer due to reduced fiber intake
Limitations for health providers
Counseling by an expert dietitian is mandatory
Limitations for the IBS patient
Following a low FODMAP diet requires highly motivated patients
It is more expensive than standard diet
Long-term adherence is not easy
Social life is hampered by restrictive diets
Reduced intake of fiber may worsen constipation-related symptoms
Lack of predictors of response to a low FODMAP diet (which IBS patient will benefit the most: constipation, diarrhea, abdominal pain, alternate, mixed?)

Gluten-free diet treatment

Gluten is the main protein found in wheat germ. Gluten is formed by the aggregation of proteins, prolamins, gliadin and glutenin in wheat. Secalin in rye and hordein in barley are proteins similar to gliadin. Zonulin is a protein that regulates intestinal permeability and is released when gliadin is present (Lammers, Vasagar & Fasano, 2014). Gluten-free diets are diets based on gluten elimination. Wheat, barley, rye, oats and products produced from these cereals (starch, flour, bread, pasta, cake, etc.) are eliminated throughout the nutritional therapy (Ulusoy & Rakıcıoğlu, 2019). The health effects of a gluten-free diet in the lack of allergies or food sensitivities have not been fully clarified (Newberry & et al., 2017). In addition, it is seen that gluten-free diet applications have recently been applied by individuals with healthy or different diseases other than celiac disease (Aziz & et al., 2014). It is suggested that wheat triggers symptoms in 23-49% of IBS patients. Gluten is associated with a higher rate of small intestinal permeability and triggers symptoms. It is also suggested that alpha-1 amylase trypsin inhibitors (ATIs) and agglutinins in wheat are triggers in the pathophysiology of IBS (Carroccio & et al., 2012; Rijnaarts & et al., 2021). In the study conducted in diarrhoea-dominant IBS patients in whom gluten-free diet was applied for six weeks, it was observed that it contributed to a decrease of 50 points or more in the IBS Symptom Severity Score (IBS-SSS) and 71% improvement in the symptoms of individuals (Aziz & et al., 2016). Individuals following a gluten-free diet also have a significant reduction in fructan intake. Therefore, it is also thought that the favourable effects of a gluten-free diet may be due to a reduction in fructans (FODMAPs) rather than gluten (Skodje & et al., 2018). However, in a study evaluating the effects of low FODMAP diet and gluten-free diet in non-celiac IBS patients, the effects of gluten on symptoms were not significant (Biesiekierski & et al., 2013). In a recent study evaluating traditional nutritional therapy, low FODMAP and gluten-free diet, it was concluded that the effect of all three diets was positive in patients with IBS, but the traditional diet was easier to be applied by individuals and it was easier to access nutrients (Anupam Rej & et al., 2022). In similar to the results of the literature, the British Dietetic Association also recommends the use of elimination diets as a third-line treatment method (McKenzie & et al., 2012).

Risks of a gluten-free diet

Gluten-free diet may increase the risk of cardiovascular diseases and obesity as a result of high consumption of saturated fatty acids, sugar and insufficient fibre intake due to the use of gluten-free products (Capili & et al., 2016; Cardo & et al., 2021). In addition to causing different diseases, it is reported to cause changes in microbiota similar to low FODMAP diet (Anupam Rej & et al., 2022). In particular, there is a decrease in beneficial bacteria such as Bifidobacterium (De Palma, & et al., 2009).

Conclusion and Suggestions

Nutritional habits of individuals play an increasingly important role in the treatment of IBS. Studies have supported the effects of low FODMAP diet and gluten-free diet applications on reducing the symptoms of individuals. However, the duration of application of these limited diets, supporting the restricted foods with alternative foods, and nutrient deficiencies that may occur in the individual are important points.

In randomised controlled trials, dietary treatments mostly show efficacy in short-term follow-up between 4 and 8 weeks. Therefore, data showing the long-term efficacy of nutritional therapies in the treatment of IBS are insufficient. Not only nutrient deficiency but also studies on microbiota are needed.

As a result, guidelines such as the British Dietetic Association and the National Institute for Health and Clinical Excellence suggest that traditional nutritional therapy should be prioritised in patients with IBS and low FODMAP diet and gluten-free diet can be followed in the following stages. However, issues such as selecting the right patient at each stage in different dietary practices, patient compliance, and the ability to implement the diet into daily life should also be emphasised.

References

Akbar, A., Yiangou, Y., Facer, P., Walters, J. R., Anand, P., & Ghosh, S. (2008). Increased capsaicin receptor TRPV1-expressing sensory fibres in irritable bowel syndrome and their correlation with abdominal pain. *Gut, 57*(7), 923-929.

Akyuz, F. (2016). İrritabl Barsak Sendromu. *Güncel Gastroenteroloji Dergisi*, *20*(4), 415-420.

Algera, J., Colomier, E., & Simrén, M. (2019). The dietary management of patients with irritable bowel syndrome: a narrative review of the existing and emerging evidence. *Nutrients, 11*(9), 2162.

Aziz, I., Karajeh, M. A., Zilkha, J., Tubman, E., Fowles, C., & Sanders, D. S. (2014). Change in awareness of gluten-related disorders among chefs and the general public in the UK: a 10-year follow-up study. *European Journal of Gastroenterology & Hepatology, 26*(11), 1228-1233.

Aziz, I., Trott, N., Briggs, R., North, J. R., Hadjivassiliou, M., & Sanders, D. S. (2016). Efficacy of a gluten-free diet in subjects with irritable bowel syndrome-diarrhea unaware of their HLA-DQ2/8 genotype. *Clinical gastroenterology and hepatology*, *14*(5), 696-703. e691.

Bagyánszki, M., Krecsmarik, M., De Winter, B. Y., De Man, J. G., Fekete, É., Pelckmans, P. A.,. Timmermans, J. P. (2010). Chronic alcohol consumption affects gastrointestinal motility and reduces the proportion of neuronal NOS-immunoreactive myenteric neurons in the murine jejunum. *The Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology, 293*(9), 1536-1542.

Barrett, J. S., & GIbson, P. R. (2007). Clinical ramifications of malabsorption of fructose and other short-chain carbohydrates. *Practical Gastroenterology, 31*(8), 51.

Bellini, M., & Rossi, A. (2018). Is a low FODMAP diet dangerous? In (Vol. 22, pp. 569-571): Springer.

Biesiekierski, J. R., Peters, S. L., Newnham, E. D., Rosella, O., Muir, J. G., & Gibson, P. R. (2013). No effects of gluten in patients with self-reported non-celiac gluten sensitivity after dietary reduction of fermentable, poorly absorbed, short-chain carbohydrates. *Gastroenterology, 145*(2), 320-328. e323.

Black, C. J., & Ford, A. C. (2020). Global burden of irritable bowel syndrome: trends, predictions and risk factors. *Nature reviews Gastroenterology & hepatology, 17*(8), 473-486.

Black, C. J., & Ford, A. C. (2021). Best management of irritable bowel syndrome. *Frontline Gastroenterol, 12*(4), 303-315. doi:10.1136/flgastro-2019-101298

Bortolotti, M., & Porta, S. (2011). Effect of red pepper on symptoms of irritable bowel syndrome: preliminary study. *Digestive diseases and sciences, 56*(11), 3288-3295.

Böhn, L., Störsrud, S., Törnblom, H., Bengtsson, U., & Simrén, M. (2013). Self-reported food-related gastrointestinal symptoms in IBS are common and associated with more severe symptoms and reduced quality of life. *Official journal of the American College of Gastroenterology| ACG, 108*(5), 634-641.

Buono, J. L., Mathur, K., Averitt, A. J., & Andrae, D. A. (2017). Economic burden of irritable bowel syndrome with diarrhea: retrospective analysis of a US commercially insured population. *Journal of managed care & specialty pharmacy, 23*(4), 453-460.

Buscail, C., Sabate, J.-M., Bouchoucha, M., Kesse-Guyot, E., Hercberg, S., Benamouzig, R., & Julia, C. (2017). Western dietary pattern is associated with irritable bowel syndrome in the French NutriNet cohort. *Nutrients, 9*(9), 986.

Capili, B., Anastasi, J. K., & Chang, M. (2016). Addressing the role of food in irritable bowel syndrome symptom management. *The Journal for Nurse Practitioners, 12*(5), 324-329.

Cardo, A., Churruca, I., Lasa, A., Navarro, V., Vázquez-Polo, M., Perez-Junkera, G., & Larretxi, I. (2021). Nutritional imbalances in adult celiac patients following a gluten-free diet. *Nutrients, 13*(8), 2877.

Carroccio, A., Mansueto, P., Iacono, G., Soresi, M., D'alcamo, A., Cavataio, F., . . . Seidita, A. (2012). Non-celiac wheat sensitivity diagnosed by double-blind placebo-controlled challenge: exploring a new clinical entity. *Official journal of the American College of Gastroenterology| ACG, 107*(12), 1898-1906.

Catassi, G., Lionetti, E., Gatti, S., & Catassi, C. (2017). The low FODMAP diet: many question marks for a catchy acronym. *Nutrients, 9*(3), 292.

Cheng, H., & Leblond, C. (1974). Origin, differentiation and renewal of the four main epithelial cell types in the mouse small intestine V. Unitarian theory of the origin of the four epithelial cell types. *American Journal of Anatomy, 141*(4), 537-561.

Chey, W. D., Hashash, J. G., Manning, L., & Chang, L. (2022). AGA Clinical Practice Update on the Role of Diet in Irritable Bowel Syndrome: Expert Review. *Gastroenterology*.

Chutkan, R., Fahey, G., Wright, W. L., & McRorie, J. (2012). Viscous versus nonviscous soluble fiber supplements: Mechanisms and evidence for fiber-specific health benefits. *Journal of the American Academy of Nurse Practitioners, 24*(8), 476-487.

Cockerell, K., Watkins, A., Reeves, L., Goddard, L., & Lomer, M. (2012). Effects of linseeds on the symptoms of irritable bowel syndrome: a pilot randomised controlled trial. *Journal of human nutrition and dietetics, 25*(5), 435-443.

Cozma-Petruţ, A., Loghin, F., Miere, D., & Dumitraşcu, D. L. (2017). Diet in irritable bowel syndrome: What to recommend, not what to forbid to patients! *World journal of gastroenterology, 23*(21), 3771.

Cuomo, R., Andreozzi, P., Zito, F. P., Passananti, V., De Carlo, G., & Sarnelli, G. (2014). Irritable bowel syndrome and food interaction. *World journal of gastroenterology: WJG, 20*(27), 8837.

De Palma, G., Nadal, I., Collado, M. C., & Sanz, Y. (2009). Effects of a gluten-free diet on gut microbiota and immune function in healthy adult human subjects. *British journal of nutrition, 102*(8), 1154-1160.

Dolan, R., Chey, W. D., & Eswaran, S. (2018). The role of diet in the management of irritable bowel syndrome: a focus on FODMAPs. *Expert review of gastroenterology & hepatology, 12*(6), 607-615.

Drossman, D. A. (2016). Functional gastrointestinal disorders: history, pathophysiology, clinical features, and Rome IV. *Gastroenterology, 150*(6), 1262-1279. e1262.

Dugum, M., Barco, K., & Garg, S. (2016). Managing irritable bowel syndrome: The low-FODMAP diet. *Cleve Clin J Med, 83*(9), 655-662.

El-Salhy, M. (2012). Irritable bowel syndrome: diagnosis and pathogenesis. *World journal of gastroenterology: WJG, 18*(37), 5151.

El-Salhy, M. (2015). Recent developments in the pathophysiology of irritable bowel syndrome. *World journal of gastroenterology: WJG, 21*(25), 7621.

El-Salhy, M., & Gundersen, D. (2015). Diet in irritable bowel syndrome. *Nutrition journal, 14*(1), 1-11.

El-Salhy, M., Patcharatrakul, T., & Gonlachanvit, S. (2021). The role of diet in the pathophysiology and management of irritable bowel syndrome. *Indian Journal of Gastroenterology, 40*(2), 111-119.

Esmaillzadeh, A., Keshteli, A. H., Hajishafiee, M., Feizi, A., Feinle-Bisset, C., & Adibi, P. (2013). Consumption of spicy foods and the prevalence of irritable bowel syndrome. *World journal of gastroenterology: WJG, 19*(38), 6465.

Eswaran, S., Farida, J. P., Green, J., Miller, J. D., & Chey, W. D. (2017). Nutrition in the management of gastrointestinal diseases and disorders: the evidence for the low FODMAP diet. *Current opinion in pharmacology, 37*, 151-157.

Fani, M., Mostamand, J., Fani, M., Chitsaz, N., & Feizi, A. (2019). The effect of aerobic exercises among women with mild and moderate irritable bowel syndrome: A pilot study. *J Bodyw Mov Ther, 23*(1), 161-165. doi:10.1016/j.jbmt.2018.02.003

Feinle-Bisset, C., & Azpiroz, F. (2013). Dietary lipids and functional gastrointestinal disorders. *Official journal of the American College of Gastroenterology| ACG, 108*(5), 737-747.

Ford, A. C., & Suares, N. C. (2011). Effect of laxatives and pharmacological therapies in chronic idiopathic constipation: systematic review and meta-analysis. *Gut, 60*(2), 209-218. doi:10.1136/gut.2010.227132

Gibson,P.R.(2011). Food intolerance in functional bowel disorders. *Journal of gastroenterology and hepatology, 26*, 128-131.

Gibson, P. R. (2017). History of the low FODMAP diet. *Journal of gastroenterology and hepatology, 32*, 5-7.

Gibson, P. R., & Shepherd, S. J. (2010). Evidence-based dietary management of functional gastrointestinal symptoms: the FODMAP approach. *Journal of gastroenterology and hepatology, 25*(2), 252-258.

Gonlachanvit, S. (2010). Are rice and spicy diet good for functional gastrointestinal disorders? *Journal of neurogastroenterology and motility, 16*(2), 131.

Gonlachanvit, S., Mahayosnond, A., & Kullavanijaya, P. (2009). Effects of chili on postprandial gastrointestinal symptoms in diarrhoea predominant irritable bowel syndrome: evidence for capsaicin-sensitive visceral nociception hypersensitivity. *Neurogastroenterology & Motility, 21*(1), 23-32.

Guo, Y.-B., Zhuang, K.-M., Kuang, L., Zhan, Q., Wang, X.-F., & Liu, S.-D. (2015). Association between diet and lifestyle habits and irritable bowel syndrome: a case-control study. *Gut and liver, 9*(5), 649.

Hadjivasilis, A., Tsioutis, C., Michalinos, A., Ntourakis, D., Christodoulou, D. K., & Agouridis, A. P. (2019). New insights into irritable bowel syndrome: from pathophysiology to treatment. *Annals of Gastroenterology, 32*(6), 554.

Halmos, E. P., Christophersen, C. T., Bird, A. R., Shepherd, S. J., Gibson, P. R., & Muir, J. G. (2015). Diets that differ in their FODMAP content alter the colonic luminal microenvironment. *Gut, 64*(1), 93-100.

Halmos, E. P., Power, V. A., Shepherd, S. J., Gibson, P. R., & Muir, J. G. (2014). A diet low in FODMAPs reduces symptoms of irritable bowel syndrome. *Gastroenterology, 146*(1), 67-75. e65.

Hayes, P., Corish, C., O'mahony, E., & Quigley, E. (2014). A dietary survey of patients with irritable bowel syndrome. *Journal of human nutrition and dietetics, 27*, 36-47.

Hayes, P. A., Fraher, M. H., & Quigley, E. M. (2014). Irritable bowel syndrome: the role of food in pathogenesis and management. *Gastroenterology & hepatology, 10*(3), 164.

Hill, P., Muir, J. G., & Gibson, P. R. (2017). Controversies and recent developments of the low-FODMAP diet. *Gastroenterology & hepatology, 13*(1), 36.

Hookway, C., Buckner, S., Crosland, P., & Longson, D. (2015). Irritable bowel syndrome in adults in primary care: summary of updated NICE guidance. *Bmj, 350*.

Houghton, L. A., Heitkemper, M., Crowell, M. D., Emmanuel, A., Halpert, A., McRoberts, J. A., & Toner, B. (2016). Age, gender, and women's health and the patient. *Gastroenterology, 150*(6), 1332-1343. e1334.

Hungin, A., Chang, L., Locke, G., Dennis, E., & Barghout, V. (2005). Irritable bowel syndrome in the United States: prevalence, symptom patterns and impact. *Alimentary pharmacology & therapeutics, 21*(11), 1365-1375.

Jamieson, A. E., Fletcher, P. C., & Schneider, M. A. (2007). Seeking control through the determination of diet: a qualitative investigation of women with irritable bowel syndrome and inflammatory bowel disease. *Clinical Nurse Specialist, 21*(3), 152-160.

Johannesson, E., Simrén, M., Strid, H., Bajor, A., & Sadik, R. (2011). Physical activity improves symptoms in irritable bowel syndrome: a randomized controlled trial. *Am J Gastroenterol, 106*(5), 915.

Karaman, N., Türkay, C., & Yönem, O. (2003). Irritable bowel syndrome prevalence in city center of Sivas. *The Turkish journal of gastroenterology: the official journal of Turkish Society of Gastroenterology, 14*(2), 128-131.

Kasap, E., Semiz, H. S., Gerçeker, E., & Yüceyar, H. (2011). İrritabl barsak sendromu ve kolonoskopi. *Endoskopi Gastrointestinal, 19*(2), 43-46.

Kellett, G. L., & Brot-Laroche, E. (2005). Apical GLUT2: a major pathway of intestinal sugar absorption. *Diabetes, 54*(10), 3056-3062.

Khan, S., & Chang, L. (2010). Diagnosis and management of IBS. *Nat Rev Gastroenterol Hepatol, 7*(10), 565-581. doi:10.1038/nrgastro.2010.137

Khayyatzadeh, S. S., Kazemi-Bajestani, S. M. R., Mirmousavi, S. J., Heshmati, M., Khoshmohabbat, S., Ferns, G. A., & Ghayour-Mobarhan, M. (2018). Dietary behaviors in relation to prevalence of irritable bowel syndrome in adolescent girls. *Journal of gastroenterology and hepatology, 33*(2), 404-410.

Kinrade SK, T. R., Fell L, Heald L, Healy A. (2014). An audit to assess feasibility and efficacy of group education for irritable bowel syndrome (İBS) patients in the delivery of low FODMAP (fermentable oligosaccharides, disaccharides, monosaccharides and polyols) dietary advice. . *Gut, 63*, 238.

Lackner, J. M., Jaccard, J., Krasner, S. S., Katz, L. A., Gudleski, G. D., & Holroyd, K. (2008). Self-administered cognitive behavior therapy for moderate to severe irritable bowel syndrome: clinical efficacy, tolerability, feasibility. *Clin Gastroenterol Hepatol, 6*(8), 899-906. doi:10.1016/j.cgh.2008.03.004

Lacy, B. E., Mearin, F., Chang, L., Chey, W. D., Lembo, A. J., Simren, M., & Spiller, R. (2016). Bowel disorders. *Gastroenterology, 150*(6), 1393-1407. e1395.

Lacy, B. E., Pimentel, M., Brenner, D. M., Chey, W. D., Keefer, L. A., Long, M. D., & Moshiree, B. (2021). ACG clinical guideline: management of irritable bowel syndrome. *Official journal of the American College of Gastroenterology| ACG, 116*(1), 17-44.

Lammers, K. M., Vasagar, B., & Fasano, A. (2014). Definition of celiac disease and gluten sensitivity. In *Celiac Disease* (pp. 13-25): Springer.

Lewis, S. J., & Heaton, K. W. (1997). Stool form scale as a useful guide to intestinal transit time. *Scandinavian journal of gastroenterology, 32*(9), 920-924.

Lovell, R. M., & Ford, A. C. (2012). Global prevalence of and risk factors for irritable bowel syndrome: a meta-analysis. *Clinical gastroenterology and hepatology, 10*(7), 712-721. e714.

McIntosh, K., Reed, D. E., Schneider, T., Dang, F., Keshteli, A. H., De Palma, G.,. Vanner,S. (2017). FODMAPs alter symptoms and the metabolome of patients with IBS: a randomised controlled trial. *Gut*, *66*(7), 1241-1251.

McKenzie, Y., Alder, A., Anderson, W., Wills, A., Goddard, L., Gulia, P., Singer, A. (2012). British Dietetic Association evidence-based guidelines for the dietary management of irritable bowel syndrome in adults. *Journal of human nutrition and dietetics, 25*(3), 260-274.

McKenzie, Y., Bowyer, R., Leach, H., Gulia, P., Horobin, J., O'Sullivan, N., Williams, M. (2016). British Dietetic Association systematic review and evidence-based practice guidelines for the dietary management of irritable bowel syndrome in adults (2016 update). *Journal of human nutrition and dietetics, 29*(5), 549-575.

Moayyedi, P., Quigley, E. M., Lacy, B. E., Lembo, A. J., Saito, Y. A., Schiller, L. R.,. Ford, A. C. (2014). The effect of fiber supplementation on irritable bowel syndrome: a systematic review and meta-analysis. *Official journal of the American College of Gastroenterology| ACG, 109*(9), 1367-1374.

Molina-Infante, J., Serra, J., Fernandez-Bañares, F., & Mearin, F. (2016). The low-FODMAP diet for irritable bowel syndrome: Lights and shadows. *Gastroenterología y Hepatología (English Edition), 39*(2), 55-65.

Müller, M., Canfora, E. E., & Blaak, E. E. (2018). Gastrointestinal transit time, glucose homeostasis and metabolic health: modulation by dietary fibers. *Nutrients, 10*(3), 275.

Newberry, C., McKnight, L., Sarav, M., & Pickett-Blakely, O. (2017). Going gluten free: the history and nutritional implications of today’s most popular diet. *Current gastroenterology reports, 19*(11), 1-8.

O'Sullivan, M. A., Mahmud, N., Kelleher, D. P., Lovett, E., & O'Morain, C. A. (2000). Patient knowledge and educational needs in irritable bowel syndrome. *European Journal of Gastroenterology & Hepatology, 12*(1), 39-43.

Özden, A., Köksal, A. Ş., Oğuz, D., Çiçek, B., Yilmaz, U., Dağli, Ü., Özler, J. (2006). Türkiye'de birinci basamak sağlık kurumlarında irritabl barsak sendromu görülme sıklığı. *Akademik Gastroenteroloji Dergisi*, *5*(1), 4-15.

Park, Y., Hunter, D. J., Spiegelman, D., Bergkvist, L., Berrino, F., Van Den Brandt, P. A., Fuchs, C. S. (2005). Dietary fiber intake and risk of colorectal cancer: a pooled analysis of prospective cohort studies. *Jama*, *294*(22), 2849-2857.

Quigley, E. M., Abdel-Hamid, H., Barbara, G., Bhatia, S. J., Boeckxstaens, G., De Giorgio, R., Tzeuton, C. (2012). A global perspective on irritable bowel syndrome: a consensus statement of the World Gastroenterology Organisation Summit Task Force on irritable bowel syndrome. *J Clin Gastroenterol*, *46*(5), 356-366. doi:10.1097/MCG.0b013e318247157c

Reding, K. W., Cain, K. C., Jarrett, M. E., Eugenio, M. D., & Heitkemper, M. M. (2013). Relationship between patterns of alcohol consumption and gastrointestinal symptoms among patients with irritable bowel syndrome. *The American journal of gastroenterology*, *108*(2), 270.

Rej, A., Aziz, I., Tornblom, H., Sanders, D., & Simrén, M. (2019). The role of diet in irritable bowel syndrome: implications for dietary advice. *Journal of internal medicine, 286*(5), 490-502.

Rej, A., Sanders, D. S., Shaw, C. C., Buckle, R., Trott, N., Agrawal, A., & Aziz, I. (2022). Efficacy and Acceptability of Dietary Therapies in Non-Constipated Irritable Bowel Syndrome: A Randomized Trial of Traditional Dietary Advice, the Low FODMAP Diet, and the Gluten-Free Diet. *Clinical gastroenterology and hepatology*.

Rijnaarts, I., Witteman, B. J., Zoetendal, E. G., Govers, C., de Wit, N. J., & de Roos, N. M. (2021). Subtypes and severity of irritable bowel syndrome are not related to patients' self-reported dietary triggers: results from an online survey in Dutch adults.

Journal of the Academy of Nutrition and Dietetics, 121(9), 1750-1762. e1758.

Satherley, R., Howard, R., & Higgs, S. (2015). Disordered eating practices in gastrointestinal disorders. *Appetite, 84*, 240-250.

Sayuk, G. S., & Gyawali, C. P. (2015). Irritable bowel syndrome: modern concepts and management options. *Am J Med, 128*(8), 817-827. doi:10.1016/j.amjmed.2015.01.036

Schmulson, M. J., & Drossman, D. A. (2017). What is new in Rome IV. *Journal of neurogastroenterology and motility*, *23*(2), 151.

Simrén, M., Månsson, A., Langkilde, A. M., Svedlund, J., Abrahamsson, H., Bengtsson, U., & Björnsson, E. S. (2001). Food-related gastrointestinal symptoms in the irritable bowel syndrome. *Digestion*, *63*(2), 108-115.

Skodje, G. I., Sarna, V. K., Minelle, I. H., Rolfsen, K. L., Muir, J. G., Gibson, P. R.,. Lundin, K. E. (2018). Fructan, rather than gluten, induces symptoms in patients with self-reported non-celiac gluten sensitivity. *Gastroenterology, 154*(3), 529-539. e522.

Spencer, M., Chey, W. D., & Eswaran, S. (2014). Dietary renaissance in IBS: has food replaced medications as a primary treatment strategy? *Current treatment options in gastroenterology*, *12*(4), 424-440.

Spiller, R. C., & Thompson, W. G. (2010). Bowel disorders. *Am J Gastroenterol*, *105*(4), 775-785. doi:10.1038/ajg.2010.69

Staudacher, H. M. (2017). Nutritional, microbiological and psychosocial implications of the low FODMAP diet. *Journal of gastroenterology and hepatology*, *32*, 16-19.

Staudacher, H. M., Lomer, M. C., Anderson, J. L., Barrett, J. S., Muir, J. G., Irving, P. M., & Whelan, K. (2012). Fermentable carbohydrate restriction reduces luminal bifidobacteria and gastrointestinal symptoms in patients with irritable bowel syndrome. *The Journal of nutrition*, *142*(8), 1510-1518.

Staudacher, H. M., Lomer, M. C., Anderson, J. L., Barrett, J. S., Muir, J. G., Irving, P. M., & Whelan, K. (2012). Fermentable carbohydrate restriction reduces luminal bifidobacteria and gastrointestinal symptoms in patients with irritable bowel syndrome. *J Nutr*, *142*(8), 1510-1518. doi:10.3945/jn.112.159285

Staudacher, H. M., & Whelan, K. (2017). The low FODMAP diet: recent advances in understanding its mechanisms and efficacy in IBS. *Gut, 66*(8), 1517-1527.

Talley, N. J., Gabriel, S. E., Harmsen, W. S., Zinsmeister, A. R., & Evans, R. W. (1995). Medical costs in community subjects with irritable bowel syndrome. *Gastroenterology, 109*(6), 1736-1741.

Tan, N., Yildirim, E., & Guldal, D. (2014). Aile Hekimliği Pratiğinde Sık Görülen Bir Hastalık: İrritabl Bağırsak Sendromu. *Turkish Journal of Family Medicine and Primary Care, 8*(3), 75-85.

Tanaka, Y., Kanazawa, M., Fukudo, S., & Drossman, D. A. (2011). Biopsychosocial model of irritable bowel syndrome. *J Neurogastroenterol Motil*, *17*(2), 131-139. doi:10.5056/jnm.2011.17.2.131

Threapleton, D. E., Greenwood, D. C., Evans, C. E., Cleghorn, C. L., Nykjaer, C., Woodhead, C., Burley, V. J. (2013). Dietary fibre intake and risk of cardiovascular disease: systematic review and meta-analysis. *Bmj, 347*.

Trinkley, K., & Nahata, M. (2011). Treatment of irritable bowel syndrome. *Journal of clinical pharmacy and therapeutics, 36*(3), 275-282.

Türk, Ö.P. (2017). *FODMAP Alımını İçeren Besin Tüketim Sıklığı Anketinin Türk Toplumuna Uyarlanması ve Validasyonu,* Yüksek Lisans Tezi, Hacettepe Üniversitesi Sağlık Bilimleri Enstitüsü, Ankara, 4.

Ulusoy, H. G., & Rakıcıoğlu, N. (2019). Glutensiz diyetin sağlık üzerine etkileri. *Beslenme ve Diyet Dergisi, 47*(2), 87-92.

Valeur, J., Røseth, A. G., Knudsen, T., Malmstrøm, G. H., Fiennes, J. T., Midtvedt, T., & Berstad, A. (2016). Fecal fermentation in irritable bowel syndrome: influence of dietary restriction of fermentable oligosaccharides, disaccharides, monosaccharides and polyols. *Digestion*, *94*(1), 50-56.

Varney, J., Barrett, J., Scarlata, K., Catsos, P., Gibson, P. R., & Muir, J. G. (2017). FODMAPs: food composition, defining cutoff values and international application. *Journal of gastroenterology and hepatology*, *32*, 53-61.

Vesa, T. H., Korpela, R. A., & Sahi, T. (1996). Tolerance to small amounts of lactose in lactose maldigesters. *Am J Clin Nutr, 64*(2), 197-201. doi:10.1093/ajcn/64.2.197

Werlang, M. E., Palmer, W. C., & Lacy, B. E. (2019). Irritable bowel syndrome and dietary interventions. *Gastroenterology & hepatology*, *15*(1), 16.

Whigham, L., Joyce, T., Harper, G., Irving, P., Staudacher, H. M., Whelan, K., & Lomer, M. (2015). Clinical effectiveness and economic costs of group versus one-to-one education for short-chain fermentable carbohydrate restriction (low FODMAP diet) in the management of irritable bowel syndrome. *Journal of human nutrition and dietetics*, *28*(6), 687-696.

Zhou, C., Zhao, E., Li, Y., Jia, Y., & Li, F. (2019). Exercise therapy of patients with irritable bowel syndrome: A systematic review of randomized controlled trials. *Neurogastroenterol Motil, 31*(2), e13461. doi:10.1111/nmo.13461

CHAPTER II

Importance of Nutrition Label and Factors Affecting Label Reading

Fatma ÇOLAKOĞLU

Introduction

Today, consumers who are aware of the relationship between nutrition and diseases have sought accurate and reliable information about the foods they eat (Topolska, Florkiewicz & Filipiak-Florkiewicz, 2021). At this point, it is seen that nutritional labels are of great importance for consumers in making the choice of buying or not buying by learning the content of packaged food products (Chen & Antonelli, 2020; Kılınç, 2023). It is reported that the correct interpretation of this label information by the individuals is effective in eliminating consumer problems related to health, safety and economic concerns (Corallo et al., 2021). In addition, these labels, which enable the consumer to establish a self-control mechanism, not only help to make the right food choices, but also contribute to the development of consumer behaviors related to adequate and balanced nutrition. (Di Noia & Prochaska, 2010; Uyar et al., 2017; Arslan, Özlü & Garipoğlu, 2022).

Nutrition labels, which are a communication tool between consumers and food business, are a part of nutritional literacy. At the same time, it has an effective role in the purchasing decisions of the consumer (Aygen, 2012; Moreira et al., 2019; Kılınç, 2023; Perumal et al., 2023). Conditions such as individual characteristics, attitudes and behaviors, and nutritional information are among the factors that affect the comprehensibility and interpretation of these labels. Studies have reported that food labeling design is also an effective factor on consumer behavior (Corallo et al., 2021; Perumal et al., 2023).

This study aimed to provide information about the importance of food labels for consumers and the factors affecting it.

Nutrition Label

Labeling is a marketing service and is mandatory for packaged foods (Honey, 2022). It has an important role in terms of providing accurate and complete information to the consumer about food safety (Mutlu 2007; Gültekin, 2019). Basically, labeling should serve the purpose of providing accurate and adequate information to consumers about the product, protecting the industry and consumers from deceptive advertising and packaging, as well as supporting a fair competition for manufacturers and increasing product sales (Einsiedel, 2000). It is known that nutritional labels are beneficial for producers as well as consumers. It is one of the goals for the producer to find the market for the product produced in the country and abroad, to adapt to international trade standards, to encourage the production of more nutritious products with the increase of confidence in the food industry (Kavas & Kınık, 2000).

Nutrition labels are defined as the printed, marked, embossed, stenciled or written health and nutrition information that the consumer sees on a packaged product they buy or to be purchase (TGK, 2017; Karademir, Bayrak & Cebirbay, 2022; Kılınç, 2023).

In order to appeal to consumers from all segments, it should contain information in a clear and understandable language, simplified, up-to-date and legally determined (Glanz, Mullis & Snyder, 1989; Egnell et al., 2018; Gültekin, 2019). Although these labels are on the back of the packaged products, there are also labels on the front of the package today (Karademir, Bayrak & Cebirbay, 2022). It is accepted as an important element that facilitates the product selection and purchasing tendency of the right individual by presenting the nutritional elements and values contained in a packaged food, the expiry date of the product, the origin, the usage and storage conditions, the production method and the ingredient list to the consumer (Einsiedel, 2000; Graham & Laska, 2012; Sonnenberg et al., 2013; Cebeci & Güneş, 2017; TGK, 2017; Gültekin, 2019; Kılınç, 2023). According to the Turkish Food Codex, product name, product ingredients and quantities, product net amount, product expiration date, usage and storage conditions, manufacturer information, health and nutrition information must be given on food labels (TGK, 2017). Although the nutritional labels, which are considered as the primary communication tool between the consumer and the manufacturer, contain complete information, the need for consumers to have technical knowledge should not be overlooked (Abbott, 1997; Egnell et al., 2018; Corallo et al., 2021).). Jeruszka-Bielak et al. (2018) reported in a study they conducted that poor understanding of food labels by the elderly may lead to an increase in heart-related health problems. In addition, the gradual decrease in nutritional awareness may increase the incidence of many chronic diseases related to hypertension, diabetes and heart (Christoph et al., 2018). Therefore, it is of great significance to educate consumers on the correct use and interpretation of food labels in order to prevent chronic diseases (Jeruszka-Bielak et al., 2018; Perumal et al., 2023).

Nutrition labeling was initiated by the Food and Agriculture Organization (FAO) in the 1970s. Singapore, Chile, the UK and Australia have a fairly reliable labeling system (Yamaguchi et al., 2022; Perumal et al., 2023). The U.S. Food and Drug Administration passed a law in 2014 to increase the readability of information by setting a minimum font size for labeling. This law regulates the labeling, presentation, advertising and nutritional labeling of foodstuffs (Vaqué, 2019). Having an easy-to-understand and reliable labeling is very effective in correcting an irregular/inadequate diet (Christoph et al., 2018; Perumal et al., 2023). The World Health Organization (WHO) recommends the use of multiple international food labeling strategies to improve nutritional labeling and prevent nutrition-related chronic diseases (Egnell et al., 2018).

Turkish Food Codex Labeling Regulation in 2010 and Turkish Food Codex Labeling and Consumer Information Regulation in 2017 were published in Turkey. Food labels and labeling system are carried out according to this regulation published in 2017 (Haydardedeoğlu, 2017). Promoting food safety and protecting consumer health are the main objectives of food legislation (Vaqué, 2019). Perumal et al. (2023) reports that food labeling design affects food choice in consumers, but reports that a labeling design framework is needed. However, it is stated that a universal labeling is not designed in line with well-defined, instructive and non-deceptive principles for nutritional labels, which consumers see as the main reference source in food selection (Corallo et al., 2021).

Functions of Nutrition Label

The vast majority of consumers focus on four critical aspects, such as the image, brand, ingredients, and nutritional information on product labels (Corallo et al., 2021). Consumers often look at the product's origin, nutritional panel and expiration date on food labels (de-Magistris, Gracia & Barreiro-Hurle, 2017).

Nutrition labels, which establish a self-control mechanism for consumers, aim to increase the quality of life with an adequate and balanced diet by ensuring that the products they buy are safe, healthy and have high nutritional value (Di Noia & Prochaska, 2010; Uyar et al., 2017; Kılınç, 2023). In order for consumers not to experience health problems related to nutrition, they should pay attention to the foods they consume and acquire the habit of reading food labels (Yıldırım, 2012). It is stated that nutritional labels, which have an important role in food safety, which has become a concern for consumers in recent years, are an effective factor in product purchase, informing consumers and business sales (Kızılaslan & Kızılaslan, 2008; Bal, 2022). Improving the quality of life by reaching the right and safe food is among the basic functions of food labels (Aygen, 2012; Kılınç, 2023). In recent studies, it is seen that the tendency of consumers to read labels has increased as a result of their demand for adequate/balanced nutrition and to maintain diet programs suitable for their chronic diseases (Di Noia & Prochaska 2010; Aygen, 2012; Coşkun & Kayışoğlu, 2018; Gültekin, 2019; Bal, 2022). Label information that facilitates consumers' food selection also provides a preventive treatment in terms of public health (Aygen, 2012; Kim, Oh & No, 2016; Moreira et al., 2019; Honey, 2022; Kılınç, 2023). Today, the fact that undecided consumers, children and women can easily access information about the product from communication sources such as the internet and television can lead to information pollution and misdirection, and can be effective in purchasing products (Özdemir & Tokol, 2008; Pettigrew et al., 2013; Cebeci & Güneş 2017). ; Kilinc, 2023). Turkish Food Codex Regulation on Food Labeling and Consumer Information has been prepared in order to ensure that foods are labeled, promoted and advertised in a way that will not mislead the consumer and enable them to make the right choice (TGK, 2017).

Factors Affecting Nutrition Label Reading

The habit and awareness of reading food labels (Corallo et al., 2021) and content, which aim to meet the social and economic expectations of the consumer, is important in the purchase of food products and in improving health awareness (Gültekin, 2019; Vaqué, 2019). Considering the studies, socio-demographic characteristics (age, education, gender, marital status), environment, health status, and social status are among the factors affecting nutritional label reading (Miller et al., 2017; Gültekin, 2019; Honey, 2022; Jeruszka.

-Bielak et al., 2018; Perumal et al., 2023). Apart from these, there are also time spent on label reading, label-related features (size, language, font) and consumer attitudes (Besler, Büyüktuncer & Uyar, 2012; Cebeci & Güneş, 2017).

Nutritional habits gained at an early age facilitate the individual's making the right choices in his future life and the perception of reading food labels (Gültekin, 2019). It is stated that while young consumers pay attention to the brand, price, expiration date and whether the package is open when purchasing packaged food (Krystallis, Maglaras & Mamalis, 2008; Alpuğuz et al., 2009), middle-aged consumers also examine the product origin information. (Krystallis, Maglaras & Mamalis, 2008). Spronk et al. (2014) stated that middle-aged consumers have higher nutritional literacy compared to younger or older consumers. Some researchers report that label information is more difficult to understand in the elderly than in the young (Cowburn & Stockley, 2005; Kim, Oh & No, 2016) and that label reading increases with increasing age, and a positive relationship is formed between label reading and age (Lin & Lee, 2003; Drichoutis, Lazaridis & Nayga, 2005; Jeruszka-Bielak et al., 2018). Although researchers have reported that educated young consumers are more likely to read food labels (Miller et al., 2017; Hakim et al., 2020), Jeruszka-Bielak et al. (2018) states that the elderly Canadian population refer to food labels as the most reliable source. In addition, the studies show that the nutritional information of consumers and the increase in the welfare of the country are used more effectively (Moreira et al., 2019; Adesina et al., 2022).

Although it is seen that the tendency to read food labels is higher in consumers with a high level of education due to the difficulty of understanding the label information (Cowburn & Stockley, 2005; Ahmadi et al., 2013; Spronk et al., 2014; Christoph et al., 2018; Jeruszka- Bielak et al., 2018) it is stated that the gender factor has an important share in the use of food labels (Spronk et al., 2014; Gül & Dikmen, 2018; Jeruszka-Bielak et al., 2018). It is reported that female consumers, especially those with higher levels of education, attach more importance to label reading than male consumers (Stran & Knol, 2013; Spronk et al., 2014; Tierney et al., 2017; Christoph et al., 2018; Gül & Dikmen, 2018; Jeruszka-Bielak et al., 2018). Studies show that high-income consumers are not inclined to read food labels. The reason for this is that these consumers shop for short periods, eat out frequently, and think that expensive products are of higher quality (Schupp, Gillespie & Reed, 1998; Drichoutis, Lazaridis & Nayga, 2005). In addition, decreased awareness of nutrition can be associated with insufficient use of food labels (Christoph et al., 2018). It has been observed that consumers who have never read the food label have changed their behavior as their age and/or education level increase (Aygen, 2012; Honey, 2022). Moreira et al. (2019) stated in their study that consumers do not read food labels due to lack of time and excessive information. It has been reported that there is a strong relationship between the use of food labels and health, and this situation is significantly higher in men with chronic diseases (Christoph et al., 2018). They observed that food labels are more beneficial for athletes, individuals with health problems, and consumers who adopt a healthy life as a principle (Moreira et al., 2019). Jeruszka-Bielak et al. (2018) stated that the group that reads food labels more carefully and deeply consists of women, the elderly and overweight consumers.

Food Labeling Design

In recent years, there have been many studies on the design of food labels and their effects on consumers. While emphasizing the necessity of simultaneous examination and evaluation of the label information along with the product (Rosenblatt et al., 2019), the main element in the label is the use of the information that the consumer will understand in a legible text size, in a regular, concise and non-technical manner (Koen et al. , 2018; Nobrega, Ares & Deliza, 2020; Schiro et al., 2020). Liang et al. (2021) argues that images, pictographs, and standardized synthesis graphics systems outperform text content in message delivery and attention-grabbing. It is stated that the color contrast is effective in the readability of the product labels on the front of the package, which acts as a poster board, and that the light blue color containers increase the consumption along with the product appearance (Wood & Tenbensel, 2018; Corallo et al., 2021). Some researchers report that standardized synthesis graphics systems, such as a traffic light system or checkmark, can guide consumers' purchasing decision and create the perception that the product is healthy and safe (Chan, Lowe & Petrovici, 2016; Nobrega, Ares & Deliza, 2020). In the traffic light labeling system, which shows the ratio of saturated fat, fat, sugar and salt, a healthy food selection is ensured by showing the high amount in red, the medium amount in yellow and the low amount in green (FSA, 2020). It is said that the triangle symbol on the white background and the warning word "High" from the warning labels attract more attention of consumers and they can make their choices more effectively (Khandpur et al., 2019). In addition, providing information about food quality and the source of verification can help raise consumer awareness of food and related verification mechanisms (Corallo et al., 2021).

Conclusion

As a result, when we look at the studies, healthy eating habits acquired at an early age enable them to make the right food choices by consciously reading and interpreting the food labels in the future. In this regard, creating social awareness and projects, especially in young consumers, and making conscious choices by gaining the habit of reading and interpreting food labels will lead to the improvement and protection of public health along with healthy and adequate nutrition. It is a necessity for consumers to carry out information campaigns that emphasize the importance and benefits of reading food labels. In addition, food business operators may contribute to the strengthening of the relationship between the producer and the consumer by using the developed/designed food labels that may be effective in attracting the attention and decision-making of the consumer.

References

Abbott, R. (1997). Food and nutrition information: a study of sources, uses and understanding. *British Food Journal*, *99*(2), 43-49. Doi: 10.1108/00070709710367265

Adesina, E., Ajayi, B., Amoo, E. O., Adeyeye, B., Ajayi, M. P., Olawande, T., Olawole- Isaac A., & Udume, M. E. (2022). Consumers' Knowledge and Use of Nutritional Labelling Information in Lagos, *Sustainability*, *14*(578), 1-16. Doi: 10.3390/su14010578

Ahmadi, A., Torkamani, P., Sohrabi, Z., & Ghahremani, F. (2013). Nutrition knowledge. Application and perception of food labels among women, *Pakistan Journal of Biological Sciences*, *16*(24), 2026–2030. Doi: 10.3923/pjbs.2013.2026.2030

Alpuğuz, G., Erkoç, F., Mutluer, B., & Selvi, M. (2009). Gençlerin (14-24 yaş) gıda hijyeni ve ambalajlı gıdaların tüketimi konusundaki bilgi ve davranışlarının incelenmesi. *Türk Hijyen ve Deneysel Biyoloji Dergisi, 66* (3), 107-115.

Arslan, E., Özlü, T., & Garipoğlu, G. (2022). Üniversite Öğrencilerinde Besin Etiketi Okuma Davranışının İncelenmesi. *Sağlık Bilimleri Dergisi*, *31*(1), 71-78. Doi: 10.34108/eujhs.915320

Aygen, F. G. (2012). Tüketicilerin Besin Etiketi İncelenmesi Konusundaki Tutum ve Davranışları. *İşletme Araştırmaları Dergisi, 4*(3), 28-54.

Bal, H. S. G. (2022). Tüketicilerin Yeni Bir Gıda Ürünü Alırken Ürün Etiketini Okumaya Olan İlgileri. *Gaziosmanpaşa Bilimsel Araştırma Dergisi*, *11*(3), 317-323.

Besler, H., Büyüktuncer, Z., & Uyar, M.F, (2012). Consumer understanding and use of food and nutrition labeling in Turkey. *Journal Nutrition Education and Behavier*, *44*(6), 584-591. Doi: 10.1016/j.jneb.2012.01.005

Cebeci, A., & Güneş, F. E. (2017). Türkiye ve Avrupa'daki Tüketicilerin Gıda Etiketi Okuma Tutumlarını Etkileyen Faktörlerin Değerlendirilmesi. *Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi*, *6*(4), 261-267.

Chan, F. F. Y., Lowe, B., & Petrovici, D. (2016). Processing of product placements and brand persuasiveness. *Marketing Intelligence & Planning, 34*(3), 1-43. Doi: 10.1108/MIP-03-2015-0051

Chen, P. J., & Antonelli, M. (2020). Conceptual models of food choice: influential factors related to foods, individual differences, and society. *Foods*, *9*(12), 1898. Doi: 10.3390/foods9121898

Christoph, M. J., Larson, N., Laska, M. N., & Neumark-Sztainer, D. (2018). Nutrition facts panels: who uses them, what do they use, and how does use relate to dietary intake? *Journal of the Academy of Nutrition and Dietetics*, *118*(2), 217-228. Doi: 10.1016/j.jand.2017.10.014

Corallo, A., Latino, M. E., Menegoli, M., & Pizzi, R. (2021). Assuring effectiveness in consumer-oriented traceability; suggestions for food label design. *Agronomy*, *11*(4), 613. Doi: 10.3390/agronomy11040613

Coşkun, F., & Kayışoğlu, S. (2018). Besin Etiketi Okuma Alışkanlıklarına ve Etiket Okumanın Satın Alma Tercihlerine Cinsiyetin Etkisi: Tekirdağ İli Örneği. *Akademik Gıda, 16*(4), 422-430. Doi: 10.24323/akademik-gida.505518

Cowburn, G., & Stockley, L. (2005). Consumer understanding and use of nutrition labelling: a systematic review. *Public Health Nutrition*, *8*(1), 21-28. Doi: 10.1079/phn2005666

De-Magistris, T., Gracia, A., & Barreiro-Hurle, J. (2017). Do consumers care about European food labels? An empirical evaluation using best-worst method. *British Food Journal*, *119*(12), 2698-2711. Doi: 10.1108/BFJ-11-2016-0562

Di Noia, J., & Prochaska, J. O. (2010). Dietary Stages Of Change And Decisional Balance: A Metaanalytic Review. *American Journal Of Health Behavior*, 34(5), 618–632. Doi: 10.5993/AJHB.34.5.11

Drichoutis, A.C., Lazaridis, P., & Nayga, R.M. (2005). Nutrition knowledge and consumer use of nutritional food labels. *European Review of Agricultural Economics*, *32*(1), 93-118. Doi: 10.1093/erae/jbi003

Egnell, M., Ducrot, P., Touvier, M., Allès, B., Hercberg, S., Kesse-Guyot, E., & Julia, C. (2018). Objective understanding of Nutri-Score Front-Of-Package nutrition label according to individual characteristics of subjects: Comparisons with other format labels. *PloS One*, *13*(8), e0202095. Doi: 10.1371/journal.pone.0202095

Einsiedel, E. (2000). Consumers and gm food labels: providing information or sowing confusion?. *AgBio Forum*, *3*(4), 231-235.

FSA (2020). *Check the label*. (09/08/2023 tarihinde https://www.food.gov.uk/safety-hygiene/check-the-label adresinden ulaşılmıştır).

Hakim, M. P., Zanetta, L. D. A., de Oliveira, J. M., & da Cunha, D. T. (2020). The mandatory labeling of genetically modified foods in Brazil: Consumer's knowledge, trust, and risk perception. *Food Research International*, 132, 109053. Doi: 10.1016/j.foodres.2020.109053

Haydardedeoğlu, M. (2017). *Avrupa Birliği Gıda Etiketleme Mevzuatının İncelenmesi ve Ulusal Mevzuatımızla Karşılaştırılması.* Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi, Sosyal Bilimler Enstitüsü. İzmir.

Glanz, K., Mullis, R., & Snyder A. (1989). Point of choice nutrition information, federal regulations and consumer health education: A critical view. *Journal of Nutrition Education*, *21*(2), 95-99. Doi: 10.1016/S0022-3182(89)80200-6

Graham, D.J., & Laska, M.N. (2012), Nutrition Label Use Partially Mediates the Relationship between Attitude toward Healthy Eating and Overall Dietary Quality among College Students, *Journal of the Academy of Nutrition and Dietetics, 112*(3), 414-418. Doi: 10.1016/j.jada.2011.08.047

Gül, F., & Dikmen, D. (2018). Kadın Tüketicilerde Besin Etiketi Okuma Alışkanlıkları ve Alerjen Bilgi Düzeyinin Saptanması. *Beslenme ve Diyet Dergisi*, *46*(2), 157- 165. Doi: 10.33076/2018.BDD.300

Gültekin, B. (2019). *Adölesanlarda sağlık algısının besin etiketi okuma alışkanlıkları üzerine etkisi*. Master's thesis, Necmettin Erbakan Üniversitesi, Sağlık Bilimleri Enstitüsü, Konya.

Jeruszka-Bielak, M., Kollajtis-Dolowy, A., Santoro, A., Ostan, R., Berendsen, A. A., Jennings, A., Meunier, N., Marseglia, A., Caumon, E., Gillings, R., de Groot L. C. P. G. M., Franceschi, C., Hieke, S., & Pietruszka, B. (2018). Are nutrition-related knowledge and attitudes reflected in lifestyle and health among elderly people? A study across five European countries. *Frontiers in Physiology*, 9, 994. Doi: 10.3389/fphys.2018.00994

Karademir, E., Bayrak, E., & Cebirbay, M. A. (2022). Gıda ve beslenme okuryazarlığının besin etiket bilgilerinin anlaşılması açısından önemi. Nazan Aktaş (Ed), *Gıda ve Beslenme Okuryazarlığı* içinde (1. baskı, s. 48-52). Ankara: Türkiye Klinikleri.

Kavas, G., & Kınık, Ö. (2000). Gıdaların Etiketlenmesi ve Etiket Standartlarına Uygunluğunun İncelenmesi. *Gıda Dergisi*, 10, 77-85.

Khandpur, N., Mais, L. A., de Morais Sato, P., Martins, A. P. B., Spinillo, C. G., Rojas, C. F. U., Garcia, M. T., & Jaime, P. C. (2019). Choosing a front-of-package warning label for Brazil: A randomised, controlled comparison of three different label designs. *Food Research International,* 121, 854-861. Doi: 10.1016/j.foodres.2019.01.008

Kılınç, K. N. (2023). Bir Beslenme Danışma Merkezine Başvuran Kadın Tüketicilerin Etiket Okuma Alışkanlıkları ve Beslenme Durumları Ilişkisi. Yüksek lisans tezi, Uludağ Üniversitesi, Bursa.

Kızılaslan, N., & Kızılaslan, H. (2008). Tüketicilerin satın aldıkları gıda maddeleri ile ilgili bilgi düzeyleri ve tutumları (Tokat İli Örneği). *Uludağ Üniversitesi Ziraat Fakültesi Dergisi, 22*(2), 67-74.

Kim, H. S., Oh, C., & No, J. K. (2016). Can nutrition label recognition or usage affect nutrition intake according to age? *Nutrition*, 32, 56-60. Doi: 10.1016/j.nut.2015.07.004

Koen, N., Wentzel-Viljoen, E., Nel, D., & Blaauw, R. (2018). Consumer knowledge and use of food and nutrition labelling in South Africa: A cross-sectional descriptive study. *International Journal of Consumer Studies, 42*(3), 335-346. Doi: 10.1111/ijcs.12422

Krystallis, A., Maglaras, G., & Mamalis, S. (2008). Motivations and Cognitive Structures of Consumers in their Purchasing of Functional Food, *Food and Quality Preference*, 19, 525-538. Doi:10.1016/j.foodqual.2007.12.005

Liang, Z., Hu, H., Xu, C., Tao, C., Geng, X., Chen, Y., Liang, F., & Jiang, D. (2021). Maria: A visual experience powered conversational agent. arXiv preprint arXiv:2105.13073. Doi: 10.48550/arXiv.2105.13073

Lin, C. T. J., & Lee, J. Y. (2003). Dietary fat intake and search for fat information on food labels: New evidence. *Consumer Interests Annual*, 49, 1-3.

Miller, L. M. S., Applegate, E., Beckett, L. A., Wilson, M. D., & Gibson, T. N. (2017). Age differences in the use of serving size information on food labels: numeracy or attention? *Public Health Nutrition, 20*(5), 786-796. Doi: 10.1017/S1368980016003219

Moreira, M. J., García-Díez, J., De Almeida, J. M. M. M., & Saraiva, C. (2019). Evaluation of food labelling usefulness for consumers. *International Journal of Consumer Studies, 43*(4), 327-334. Doi: 10.1111/ijcs.12511

Mutlu, S. (2007). *Gıda Güvenirliği Açısından Tüketici Davranışları: Adana Kentsel Kesimde Kırmızı Et Tüketimi Örneğ*i. Doktora Tezi, Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Tarım Ekonomisi Anabilim Dalı, Adana.

Nobrega, L., Ares, G., & Deliza, R. (2020). Are nutritional warnings more efficient than claims in shaping consumers' healthfulness perception? *Food Quality and Preference,* 79, 103749. Doi: 10.1016/j.foodqual.2019.103749

Özdemir, E., & Tokol, T. (2008). Kadın tüketicilere yönelik pazarlama stratejileri. *Anadolu University Journal of Social Sciences,* 8, 57–80.

Perumal, K., Balakrishnan B., Idris MZB., & Sandow, KR. (2023). The factors and issues affecting food labelling and the need for labelling design framework: a review. *Muallim Journal of Social Sciences and Humanities,* 7(1), 53-61.Doi: 10.33306/mjssh/224

Pettigrew, S., Talati, Z., Hughes, C., Miller, C., Shilton, T., Ball, K., Neal B., Dixon H., & Kelly, B. (2016). Consumers' assessments of different categories of frontof- pack food labels. *European Journal of Public Health*, 26, 280-U72. Doi: 10.1093/eurpub/ckw172.023

Rosenblatt, D. H., Dixon, H., Wakefield, M., & Bode, S. (2019). Evaluating the influence of message framing and graphic imagery on perceptions of food product health warnings. *Food Quality and Preference,* 77, 32-42. Doi: 10.1016/j.foodqual.2019.05.003

Schiro, J. L., Shan, L. C., Tatlow-Golden, M., Li, C., & Wall, P. (2020). Healthy: smart digital food safety and nutrition communication strategies—a critical commentary. *NPJ Science of Food, 4*(1), 1-11. Doi: 10.1038/s41538-020-00074-z

Schupp, A., Gillespie, J., & Reed, D. (1998). Consumer Awareness and Use of Nutrition Labels and Packaged Fresh Meats: A Pilot Study. *Journal of Food Distribution Research*, 24-30.

Sonnenberg, L., Gelsomin, E., Levy, D. E., Riis, J., Barraclough, S., & Thorndike, A. N. (2013). A traffic light food labeling intervention increases consumer awareness of health and healthy choices at the point-of-purchase. *Preventive Medicine*. *57*(4), 253-257. Doi: 10.1016/j.ypmed.2013.07.001

Spronk, I., Kullen, C., Burdon, C., & O'Connor, H. (2014). Relationship between nutrition knowledge and dietary intake. *British Journal of Nutrition*, *111*(10), 1713–1726. Doi: 10.1017 /s0007114514000087

Stran, K.A., & Knol, L.L. (2013). Determinants of Food Label Use Differ By Sex. *Journal of the Academy of Nutrition and Dietetics*, *113*(5), 2212-2672. Doi: 10.1016/j.jand.2012.12.014

Tierney, M., Gallagher, A. M., Giotis, E. S., & Pentieva, K. (2017). An online survey on consumer knowledge and understanding of added sugars. *Nutrients, 9*(1), 37.

TGK (2017). *Gıda Etiketleme ve Tüketicileri Bilgilendirme Yönetmeliğ*i. (08/08/2023 tarihinde https://www.resmigazete.gov.tr/eskiler/2017/01/20170126M1-6.htm adresinden ulaşılmıştır).

Topolska, K., Florkiewicz, A., & Filipiak-Florkiewicz, A. (2021). Functional food—Consumer motivations and expectations. *International Journal of Environmental Research and Public Health*, *18*(10), 5327. Doi: 10.3390/ijerph18105327

Uyar, F., Özmen, D., Tayhan, A,, & Büyük, D.Ş. (2017). Erişkinlerin gıda alışverişi sırasında etiket okuma alışkanlıkları ve genetiği değiştirilmiş organizmalar konusundaki görüşleri. *International Journal of Human Sciences*. 14(3), 2555-2576.

Vaqué, L. G. (2019). Nutritional information for consumers– is it really useful? Limits and future prospects. In Altinay Urazbaeva, Anna Szajkowska, Bart Wernaart, Nikolaas Tilkin Franssens, Rozita Spirovska Vaskoska (Eds.), *The functional field of food law: Reconciling the market and human rights* (pp. 331-344). Netherlands: Wageningen Academic Publishers.

Wood, A., & Tenbensel, T. (2018). A comparative analysis of drivers of collaborative governance in front-of-pack food labelling policy processes. *Journal of Comparative Policy Analysis: Research and Practice*, *20*(4), 404-419. Doi: 10.1080/13876988.2017.1391462

Yamaguchi, M., Nomura, M., Arai, Y., Vandevijvere, S., Swinburn, B., & Nishi, N. (2022). An assessment of implementation gaps and priority recommendations on food environment policies: the Healthy Food Environment Policy Index in Japan. *Public Health Nutrition*, *25*(6), 1720-1732. Doi: 10.1017/S1368980021004900

Yıldırım, S. (2012). *Besin Etiketlerinin Tüketici Talebine Etkisi: İstanbul- Ankara- İzmir İllerinde Bir Çalışma.* Yüksek lisans tezi, Celal Bayar Üniversitesi, Sosyal Bilimler Enstitüsü, Manisa.

CHAPTER III

Importance of Functional Foods

Gökhan DEGE[1]

Introduction

Nutrition plays a crucial role in enhancing health and fostering a higher quality of life, and it is recognized as a modifiable factor influencing health. The World Health Organization (WHO), in its 2022 report, underscored the pivotal role of nutrition by emphasizing the significance of functional foods. Over time, numerous theories about functional foods have emerged, and people select them for specific reasons. The expanding variety of foods in the market has heightened people's scrutiny of food content, contributing to the rising popularity of functional foods. Notably, individuals aged 18-24 exhibit a more favorable attitude towards functional foods compared to other age groups. When integrated into daily diets and consumed in various ways, these foods can manifest their claimed beneficial effects (Akbulut, 2019).

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Various factors, such as changes in lifestyle, increasing affluence, urbanization, unhealthy diet, physical inactivity, tobacco use, and harmful alcohol consumption, have resulted in a surge in non-communicable diseases. This, in turn, has led to increased healthcare costs and diminished quality of life (John, 2021; Plasek et al., 2020; WHO, 2023). Functional foods aim to optimize nutrition and promote maximum well-being, health, and quality of life. They also strive to enhance physiological functions and mitigate the risk of non-communicable diseases (Nystrand & Olsen, 2021).

The concept of functional nutrients was initially proposed by the Japanese academic community as 'Foods for Specific Health Uses' (FOSHU) (Arai 1996). Over time, Europe and America have taken various steps regarding functional foods, establishing organizations like the European branch of the International Life Sciences Institute (ILSI), which initiated the 'Functional Food Science in Europe (FUFOSE)' project (AT.D 1999). In the United States, different organizations, including the American Dietetic Association (ADA), the International Life Sciences Institute of North America (ILSI NA), and the Food and Nutrition Board of the Institute of Medicine (FNB), have provided distinct working definitions of functional foods. However, the Food and Drug Administration (FDA) has not offered a specific definition.

The ADA defines functional foods as "All nutrients can be classified as functional at some physiologic level," emphasizing that fortified or enriched foods can potentially benefit health when consumed (Hasler, Hasler). Health Canada (HC) defines functional foods as "foods that are consumed as part of a normal diet, have or resemble the appearance of a traditional food, have physiological benefits beyond basic nutritional functions, and contain bioactive components that can reduce the risk of chronic disease" (Shahidi, 2009). The Functional Food Center (FFC) defines functional foods as "Natural or processed foods containing biologically active compounds that, in defined, effective, non-toxic amounts, provide a clinically proven and documented health benefit using specific biomarkers to support optimal health and reduce the risk of chronic/viral disease and manage its symptoms.

In Turkey, the concept of 'functional foods' was officially introduced into legislation on June 5, 2004, under the provisions of Law No. 5179, which pertains to the production, supervision, and consumption of food. As per this law, functional foods are defined as "foods that, in addition to their nutritional effects, possess scientifically and clinically proven health-protective, health-improving, and/or disease risk-reducing effects through the activity of one or more components" (Siro Kapolan, 2008). While a universally accepted common definition for functional foods is still lacking, there is an emerging consensus that certain foods exert beneficial effects beyond conventional nutrition (Shahidi, 2009; Haslar 2009).

Key characteristics of functional foods, as identified in the literature, include:

Contribution to nutrition and promotion of health protection and improvement.

Substantiated evidence of positive health effects supported by both nutritional and medical science.

Consumption based on reliable scientific data regarding the nutrient or its components.

Determination of the effects of relevant nutrient components through quantitative and qualitative methods.

Preservation of nutritional properties if the food gains functional attributes through processing.

Inclusion of functional foods as a regular part of the normal diet.

Natural consumability, without presentation in pill or capsule form (Arayıcı, 2020; Coşkun, 2005; Şimşek et al., 2017; Tekün, 2015).

Functional nutrients can be classified in various ways, and there is no universal consensus on the categorization. The Canadian Department of Agriculture and Rural Affairs outlines three primary categories of functional foods:

Naturally Functional Foods: These are foods that inherently contain functional ingredients, such as tomatoes rich in lycopene or carrots containing beta-carotene.

Processed Foods with Added Ingredients: This category includes processed foods that have additional functional ingredients, such as fruit juices and calcium-enriched milks.

Foods with Enhanced Functional Ingredients: This group comprises foods that have been enriched through methods like genetic engineering, resulting in higher levels of functional components like lycopene in tomatoes (Government of Canada, 2022).

In explaining the concept of functional foods, the American Dietetic Association (ADA) underscores that the intention is not to categorize foods as good or bad but to acknowledge that all natural foods can be part of a healthy and diverse diet (Hasler, 2009). The ADA, along with several other sources, classifies functional foods into three or four main categories:

Natural Traditional Foods: These are natural foods containing ingredients developed under specific agricultural conditions.

Modified/Modified Foods: This category encompasses fortified, enriched, modified, and improved nutrients, where ingredients are either removed or added to mitigate negative health effects or enhance positive effects.

Medicinal Foods: These are formulated to be consumed under the supervision of a physician or administered enteral, intended for the specific dietary management of a particular disease or condition, with nutritional requirements determined by medical evaluation based on recognized scientific principles.

Special Nutrition Products for Certain Diets: This category includes products designed for specific dietary needs, such as gluten-free nutritional products for celiac patients or specialty foods for infants.

Functional Nutrients and Health Benefits

Terpenes (Isoprenoids)

Terpenes represent a class of plant metabolites that stand out for their remarkable functional and structural diversity, being present in both animals and plants (Vranova et al., 2012). Playing a pivotal role in shaping the taste, aroma, and color of plants, terpenes constitute the primary components of essential oils found in select plant species. Beyond their sensory attributes, terpenes also serve medicinal purposes, with examples found in citrus fruits, thyme, menthol, and cannabis (Cox-Georgian et al., 2019).

These compounds, discovered in sediment 2.5 billion years ago, are naturally occurring and boast a diverse family of over 23,000 identified members. Terpenes are categorized based on the number of isoprene moieties, and the terms "terpene" and "terpenoid" are often used interchangeably, though subtle differences exist. Terpenes typically exhibit a hydrocarbon structure and may include oxygen-containing elements such as alcohols, aldehydes, and ketones; those with such oxygen-containing structures are specifically termed terpenoids (Cox-Georgian et al., 2019; Food-Info, 2022).

Terpenes serve as functional compounds within organisms, contributing to both antagonistic and beneficial interactions. Their medicinal potential is actively explored, particularly in fields such as oncology, anti-inflammatory treatments, and antiparasitic applications. Plants rich in terpenes, notably cannabis, tea, thyme, Spanish sage, and citrus fruits, have been extensively studied for their therapeutic properties. In recent times, tea tree oil, recognized for its antimicrobial efficacy, has gained prominence and is increasingly preferred in the treatment of skin infections (Carson et al., 2006).

Carotenoids

Carotenoids are tetraterpenes, counted among the natural functional components, and are generally responsible for a wide range of colors, spanning from yellow to red (Ankaralıgil & Güneşer, 2021; Özgen Özkaya, 2021). Studies have demonstrated the anticarcinogenic effects of various carotenoids. Lycopene, a carotenoid present in foods like tomatoes, functions as a vitamin A-like compound in the body and may reduce the risk of prostate, breast, digestive system, bladder, skin, and cervical cancer due to its antioxidant properties (Coşkun, 2005). Another significant carotenoid, lutein, cannot be synthesized in the body and serves as a dietary bioactive component found in green leafy vegetables. Additionally, lutein contributes to maintaining cognition and a healthy visual system (Wallace et al., 2015). Chlorophylls and carotenoids are not naturally synthesized in animal tissues but can be obtained externally. Therefore, it is necessary to derive these molecules from food (Giuffrida, 2007). However, not all natural sources of these components are consistently present in our normal dietary habits. It is estimated that around 40 carotenoids can be absorbed, metabolized, and/or utilized in our body. However, when considering the carotenoid profile typically detectable in human blood plasma, this number can be as low as 6 (Fernández-García, 2012). Carotenoids can be further divided into provitamin A and non-provitamin A compounds

Dietary Fiber

Dietary fiber, a complex carbohydrate exclusively found in plants, comprises non-starch polysaccharides, including cellulose, pectin, and lignin (Ankaralıgil & Güneşer, 2021). Certain studies indicate that ingested polysaccharides and their derivative, fructooligosaccharides, play a crucial role in sustaining a healthy symbiotic relationship between humans and gut bacteria (D.

Martirosyan et al., 2022). Soluble fibers with a low glycemic index, such as psyllium and inulin, exhibit potential beneficial effects on glucose metabolism and insulin sensitivity (John & Ankit, 2021; Schlienger, 2010). Moreover, soluble fibers have demonstrated the ability to reduce concentrations of low-density lipoprotein (LDL) cholesterol, particularly in individuals with elevated lipoprotein levels.

Furthermore, diets rich in antioxidants, such as plant flavonoids, have been shown to prevent LDL oxidation. They also inhibit the production of cell-to-cell adhesion factors that can harm arterial endothelium and contribute to the formation of blood clots (Howlett, 2008).

Essential Fatty Acids

Long-chain essential fatty acids, crucial for maintaining cholesterol balance, are not naturally synthesized in the body and must be acquired through diet (Ankaralıgil & Güneşer, 2021; Yılmaz, 2021). Among these, omega-3 fatty acids encompass alpha-linolenic, docosahexaenoic (DHA), and eicosapentaenoic (EPA) fatty acids (Vattem & Maitin, 2016). Omega-3 fatty acids have been associated with a reduced risk of cardiovascular diseases, cancer, and diabetes. They also contribute to enhancing immune system function and alleviating clinical symptoms in conditions such as allergic diseases, rheumatoid arthritis, dermatological, psychological, and neurological disorders. Additionally, there is speculation that omega-3 fatty acids may help in delaying age-related cognitive decline (Özgen Özkaya, 2021).

Epidemiological data suggests that a diet deficient in polyunsaturated fatty acids is linked to an increased risk of chronic diseases, including cancer, cardiovascular diseases, and diabetes (D. Martirosyan et al., 2022). Polyunsaturated fatty acids can be incorporated into cell membranes, reducing the availability of arachidonic acid for the synthesis of proinflammatory eicosanoids. They can also diminish the production of inflammatory cytokines.

However, caution is advised as excessive consumption of polyunsaturated fatty acids may lead to oxidative damage, particularly affecting cellular structures such as blood vessel walls—a characteristic feature in the development of cardiovascular diseases (D. Martirosyan et al., 2022).

Prebiotics, Probiotics and Synbiotics

In prebiotic applications, products containing fructooligosaccharides (FOS) and galactooligosaccharides (GOS) have been commonly favored. Studies conducted across varying application durations, ranging from 4 hours to 4 weeks, revealed no discernible difference between prebiotic users and non-users, particularly in relation to anxiety states. Consequently, it is deduced that the use of prebiotics does not exert a therapeutic effect on depression or anxiety. Lactobacillus, among the emphasized species in probiotics, exhibits a significant difference in effect size compared to other probiotics. However, despite these findings, no notable impact of Lactobacillus on anxiety has been observed (Li et al., 2019).

Probiotics, beneficial microorganisms primarily classified as lactic acid bacteria, play a crucial role in intestinal health. They are defined as "living microorganisms that provide health benefits to the host when administered in adequate amounts" (Dahiya & Nigam, 2022). Research indicates that probiotics possess various health-promoting properties, including enhancing gut health, fortifying the immune response, and reducing serum cholesterol (Damian et al., 2022). These benefits encompass preventing the colonization or inhibiting the growth of pathogenic bacteria, reinforcing epithelial barrier functions, stimulating the host's immune response, and modulating inflammatory gene expression in the gut (Bousdoini et al., 2022).

Synbiotics, defined as "a mixture of live microorganisms and substrate that is selectively utilized by host microorganisms and offers a health benefit to the host" (Dahiya & Nigam, 2022), involve a combination of probiotics and prebiotics. Their objective is to modify gut flora and metabolism, thereby enhancing the survival rate of health-promoting bacteria (Ashwell, 2002).

Soy Proteins

Soy products exhibit activity similar to estrogen, a pivotal hormone known for its impact on bone health and role in bone mass regulation. Research exploring the influence of soy products on bone mass suggests that this effect may arise from the estrogen-like activity of soy isoflavones or the calcium content they possess. However, definitive conclusions remain elusive (Pisani et al., 1999).

Fermented soybean products have garnered significant attention in the medical field owing to their high protein content. Numerous studies have investigated the reported beneficial effects of soy on nutrition and health. A study by Bhathena et al. demonstrated that soy products rich in isoflavones can exhibit anti-diabetic effects. Additionally, soybean extract was observed to inhibit glucose uptake at the cellular level (Bhathena et al., 2002). Other studies have indicated that individuals in eastern cultures, where soy consumption is higher, demonstrate lower susceptibility to breast cancer compared to those in western cultures (Cho et al., 2011). According to Li et al.'s 2019 review, soy consumption is associated with positive effects on LDL, HDL, TG, and total cholesterol levels, especially in individuals with hypercholesterolemia (Li et al., 2019).

Flavonoids

Flavonoids, extensively researched for their antioxidant properties, play a significant role in combating reactive oxygen and free radical species that trigger inflammation. Their anti-inflammatory, antiviral, and antiallergenic properties have been the focus of intensive studies (Akbulut, 2019). These natural compounds, with over 4000 varieties, are thought to be abundant, particularly in foods like tea, apples, tomatoes, and red wine (Kahraman et al., 2002).

Proanthocyanidins, among the most consumed flavonoids, boast an average daily dietary intake of 242 mg due to their high molecular weight. Following proanthocyanidins in dietary flavonoid intake are flavanones (102 mg), flavanols (34 mg), anthocyanins (27 mg), flavonols (27 mg), flavones (5 mg), and finally, isoflavones (1 mg) (Akhlaghi et al., 2018). A study exploring the effects of chocolate on skin and heart health revealed chocolate's popularity due to its accessibility and affordability as a dessert option. The positive health effects of chocolate, attributed to the flavonoids it contains, have garnered attention. Notably, chocolate has shown a protective effect against heart diseases, as suggested by recent meta-analysis studies demonstrating its positive impact on heart disease, stroke, diabetes, and cognition (Tan et al., 2021). A systemic review in 2019 delved into the effects of cocoa and dark chocolate on weight loss. The review concluded that consuming 30 grams of cocoa or dark chocolate daily for at least one month proved effective in reducing Body Mass Index (BMI) and body weight (Kord-Varkaneh et al., 2018).

Conclusion

In conclusion, the significance of functional foods in promoting overall health and well-being cannot be overstated. As we navigate the complexities of modern lifestyles and face the challenges of an evolving global health landscape, the role of functional foods emerges as a crucial factor in disease prevention and optimal nutrition. The unique blend of bioactive compounds, vitamins, and minerals found in these foods not only provides essential nutrients but also offers potential therapeutic benefits. By incorporating functional foods into our daily diets, we empower ourselves to proactively manage and improve our health, reducing the risk of chronic diseases and enhancing our overall quality of life. As research continues to uncover new insights into the intricate relationship between nutrition and health, the promotion and consumption of functional foods stand as a proactive and practical approach to fostering a healthier, more resilient society.

References

Akbulut, G. (2019). Krause.Besin ve Beslenme Bakım Süreci, Ankara, Nobel Tıp, 14. Baskı.

Akhlaghi, M., Ghobadi, S., Hosseini, M., Gholami, Z., & Muhmadian, F. (2018). Flavanols Are Potential Anti-Obesity Agents, A Systematic Review And Meta-Analysis Of Controlled Clinical Trials. *Nutrition, Metabolism And Cardiovascular Diseases, 28*(7), 675-690.

Akhlaghi, M., Ghobadi, S., Hosseini, M., Gholami, Z., & Muhmmadian, F. (2018), “Flavanols are potential anti-obesity agents, a systematic review and meta-analysis of controlled clinical trials, *Nutrition, Metabolism And Cardiovascular Diseases, 28*(7), 675-690.

Ankaraligil, P., & Guneser, B. (2021). "Fonksiyonel Gıda Bileşenlerinin Tespit Edilmesinde Enstrümental Analiz Tekniklerinin Önemi". *European Journal of Science and Technology, 28*, 251–258. https://doi.org/10.31590/ejosat.995395

Arai, S. (1996). Studies on functional foods in Japan—state of the art. *Bioscience, Biotechnology, and Biochemistry, 60*(1), 9-15.

Arayıcı, M. E. (2020). Ege Üniversitesi Ebelik, Diyetisyenlik ve Hemşirelik Öğrencilerinin Doğal Fonksiyonel Besinler Hakkında Bilgi Düzeyleri ve Tutumları. Ege Üniversitesi. (Yüksek Lisans Tezi), Sağlık Bilimleri Enstitüsü Halk Sağlığı Anabilim Dalı, Ege Üniversitesi.

Ashwell, M. (2002). “Concepts of Functional Food”, ILSI EUROPE Concise Monograph series. Retrieved from https://ilsi.eu/wpcontent/uploads/sites/3/2016/06/C2002Con_Food.pdf

AT, D., & Action, E. C. (1999). Scientific concepts of functional foods in Europe: Consensus document. Br. J. Nutr, 81, S1-S27.

Bhathena, S. J., Ali, A. A., Mohamed, A. I., Hansen, C. T., & Velasquez, M. T. (2002). Differential effects of dietary flaxseed protein and soy protein on plasma triglyceride and uric acid levels in animal models. *The Journal of Nutritional Biochemistry, 13*(11), 684-689.

Bousdoini, P., Kandylıarı, A., & Koutelidakis, A. E. (2022). "Probiotics and Phytochemicals: Role on Gut Microbiota and Efficacy on Irritable Bowel Syndrome, Functional Dyspepsia, and Functional Constipation". *Gastrointestinal Disorders, 4*(1), 30–48. https://doi.org/10.3390/gidisord4010005

Carson, C., Hammer, K., & Riley, T. (2006). Melaleuca Alternifolia (Tea Tree) Oil: A Review Of Antimicrobial And Other Medicinal Properties. ASM Journals, 19(1), 50-62.

Cho, K. M., Lee, J. H., Yun, H. D., Ahn, B. Y., Kim, H., & Seo, W. T. (2011). Changes of phytochemical constituents (isoflavones, flavanols, and phenolic acids) during cheonggukjang soybeans fermentation using potential probiotics Bacillus subtilis CS90. *Journal of Food Composition and Analysis, 24*(3), 402-410.

Coşkun, T. (2005). Fonksiyonel besinlerin sağlığımız üzerine etkileri. *Çocuk Sağlığı ve Hastalıkları Dergisi, 48*, 69–84.

Cox-Georgian, D., Ramadoss, N., Dona, C., & Basu, C. (2019). Therapeutic And Medicinal Uses of Terpenes. Medicinal Plants: From Farm to Pharmacy, 333-359.

Dahiya, D., & Nigam, P. S. (2022). "Probiotics, Prebiotics, Synbiotics, and Fermented Foods as Potential Biotics in Nutrition Improving Health via Microbiome-Gut-Brain Axis". *Fermentation, 8*(7). https://doi.org/10.3390/fermentation8070303

Fernández-García, E., Carvajal-Lérida, I., Jarén-Galán, M., Garrido-Fernández, J., Pérez-Gálvez, A., & Hornero-Méndez, D. (2012). Carotenoids bioavailability from foods: From plant pigments to efficient biological activities. *Food Research International, 46*(2), 438-450.

Giuffrida, D., Salvo, F., Salvo, A., La Pera, L., & Dugo, G. (2007). Pigments composition in monovarietal virgin olive oils from various Sicilian olive varieties. *Food Chemistry, 101*(2), 833-837.

Government of Canada. (n.d.). Nutraceuticals/Functional Foods and Health Claims On Foods. Retrieved from https://www.canada.ca/en/health-canada/services/foodnutrition/food-labelling/health-claims/nutraceuticals-functional-foods-healthclaims-foods-policy-paper.html

Hasler, C. M., & Brown, A. C. (2009). Position of the American Dietetic Association: functional foods. *Journal of the American Dietetic Association, 109*(4), 735-746.

Hasler, C. M., Bloch, A. S., Thomson, C. A., Enrione, E., & Manning, C. (2004). Position of the American Dietetic Association: functional foods. *Journal of the American Dietetic Association, 104*(5), 814-826.

Howlett, J. (2008). Functional Foods From Science Health and Claims. ILSI EUROPE Concise Monograph series. https://ilsi.eu/wpcontent/uploads/sites/3/2016/06/C2008Func_Food Eng.pdf

John, R., & Ankit, S. (2021). "Functional Foods: Components, health benefits, challenges, and major projects". DRC Sustainable Future: *Journal of Environment, Agriculture, and Energy*, June, 61–72. https://doi.org/10.37281/drcsf/2.1.7

Kahraman, A., Serteser, M., & Koken, T. (2002). Flavonoidler. *Kocatepe Tıp Dergisi, 3,* 01-08.

Kord-Varkaneh, H., Ghaedi, E., Nazary-Vanani, A., Mohammadi, H., & Shab-Bidar, S. (2019), "Does Cocoa/Dark Chocolate Supplementation Have Favorable Effect On Body Weight, Body Mass Index And Waist Circumference? A Systematic Review, Meta-Analysis And DoseResponse Of Randomized Clinical Trials", *Critical Reviews In Food Science And Nutrition, 59*(15), 2349-2362.

Li, N., Wu, X., Zhuang, W., Xia, L., Chen, Y., Zhao, R., Yi, M., Wan, Q., Du, L., & Zhou, Y. (2020). Soy and Isoflavone Consumption and Multiple Health Outcomes: Umbrella Review of Systematic Reviews and Meta-Analyses of Observational Studies and Randomized Trials in Humans. *Molecular Nutrition Food Research, 64*(4), 1-12.

Martirosyan, D., Lampert, T., & Lee, M. (2022). A comprehensive review on the role of food bioactive compounds in functional food science. *Functional Food Science, 2(*3), 64. https://doi.org/10.31989/ffs.v2i3.906

Nystrand, B. T., & Olsen, S. O. (2021). Relationships between functional food consumption and individual traits and values: A segmentation approach. *Journal of Functional Foods, 86*(May). https://doi.org/10.1016/j.jff.2021.104736

Ozgen Ozkaya, S. (2021). Yaşam Kalitesi ve Fonksiyonel Besinler. *Sağlık Bilimleri Dergisi, 1*(1), 62–68.

Pisani, P., Parkin, D. M., Bray, F., & Ferlay, J. (1999). Erratum: Estimates of the worldwide mortality from 25 cancers in 1990. *International Journal of Cancer, 83*(6), 870-873.

Plasek, B., Lakner, Z., Kasza, G., & Temesi, Á. (2020). Consumer evaluation of the role of functional food products in disease prevention and the characteristics of target groups. *Nutrients, 12*(1). https://doi.org/10.3390/nu12010069.

Schlienger, J. L. (2010). Functional foods. In European Commission (Vol. 2, Issue 4). https://doi.org/10.1016/s1957-2557(08)74030-6

Shahidi, F. (2009). Nutraceuticals and functional foods: whole versus processed foods. *Trends in Food Science & Technology, 20*(9), 376-387.

Siró, I., Kápolna, E., Kápolna, B., & Lugasi, A. (2008). Functional food. Product development, marketing and consumer acceptance—A review. *Appetite, 51*(3), 456-467.

Şimşek, N., Taştan, H., & Dönmez, B. (2017). "Fonksiyonel Gıdaların Yararlı Bulunması ve Kullanım Sıklığı İlişkisi". Turizmin Geleceği: İnovasyon, Girişimcilik ve Sürdürülebilirlik Konulu Birinci Uluslararası Kongre, October, Mersin. https://www.researchgate.net/publication/320169831_Fonksiyonel_Gidalarin _Yararli_Bulunmasi_ve_Kullanim_Sikligi_Iliskisi

Tan, T., Lim, X., Yeo, J., Lee, S., & Lai, N. (2021), "The Health Effects Of Chocolate And Cocoa: A Systematic Review", *Nutrients, 13*(9), 2909.

Tekün, E. (2015). "Farklı Eğitim Düzeylerindeki Obez Olan ve Olmayan Bireylerin Fonksiyonel Besinleri Kullanma Durumlarının Belirlenmesi". (Yüksek Lisans Tezi), Sağlık Bilimleri Enstitüsü Beslenme ve Diyetetik, Haliç Üniversitesi.

Vattem, D. A., & Maitin, V. (2015). "Functional Foods, Nutraceuticals and Natural Products: Concepts and Applications", DEStech Publications, Pennsylvania, U.S.A. https://gavsispanel.gelisim.edu.tr/Document/bgcol/20190220115348732_dcfb1798- bc12-4788-a50f-ec72d7f69ef4.pdf

Vranova, E., Coman D., & Gruissem, W. (2012). Structure and Dynamics Of The Isoprenoid Pathway Network. *Molecular Plant, 5(*2), 318-333.

Wallace, T. C., Blumberg, J. B., Johnson, E. J., & Shao, A. (2015). Dietary bioactives: Establishing a scientific framework for recommended intakes. *Advances in Nutrition, 6*(1), 1–4. https://doi.org/10.3945/an.114.007294

Wallace, T. C., Blumberg, J. B., Johnson, E. J., & Shao, A. (2015). Dietary bioactives: Establishing a scientific framework for recommended intakes. *Advances in Nutrition, 6*(1), 1–4. https://doi.org/10.3945/an.114.007294

World Health Organization. (n.d.). A healthy lifestyle - recommendations. Retrieved from https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle--- who-recommendations

World Health Organization. (n.d.). Obesity and Overweight. Retrieved from https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

Yilmaz, N. A. (2021). “Kırklareli İli Babaeski İlçesinde Yaşayan Obez Olan veya Obez Olmayan Bireylerin Fonksiyonel Besinler Hakkinda Bilgi ve Tutumlarına Dair Araştırma” , (Yüksek Lisans Tezi), Sağlık Bilimleri Enstitüsü Beslenme ve Diyetetik Anabilim Dalı, Trakya Üniversitesi.

CHAPTER IV

The Effect of Omega-3 Fatty Acids on Mental Development

Elif Ebru ALKAN

Mechanisms of Action of ω-3 Fatty Acids

Omega-3 fatty acids, particularly DHA, are critical long-chain polyunsaturated fatty acids of paramount importance to human health. DHA, mainly found in the brain and retina, plays a vital role (4). Eicosapentaenoic acid (EPA, 20:5 ω-3) and docosahexaenoic acid (DHA, 22:6 ω-3) are essential nutrients for growth and normal cellular functions. DHA is indispensable for the continuous development and maintenance of the central nervous system's normal structure and functions . Polyunsaturated fatty acids, comprising both n-3 and n-6 fatty acids, form approximately between 15 and 30 percent of the dry weight of the brain and can influence gene expression in the brain, cell membrane structure, and electrophysiological properties. DHA and AA, which make up roughly 6% of the dry weight of gray matter, are the main fatty acids in cell membrane phospholipids (5,6). Docosahexaenoic acid regulates membrane fluidity, thereby influencing the function of barrier between brain and blood, neurotransmitter release, Na+/K+-dependent ATPase, and the activities of membrane-bound receptors (e.g., rhodopsin) (7.8). Furthermore, DHA plays a role in gene expression involved in synaptic plasticity, endocytosis, signal transmission, and synaptic vesicle recycling and serves as a precursor for anti-inflammatory compounds like resolvins and neuroprotectins (9). The speed of signal transmission, defined as the rate of information transfer from one neuron to another, is a fundamental cognitive process, and there is evidence suggesting that DHA enhances signal transmission speed (10). Alpha-linolenic acid (ALA), which is the primary source of nutrients for brain function, has yet to have its requirements definitively determined; however, it is suggested that it should comprise 0.5% of daily energy intake (11).

Omega-3 Fatty Acids and Cognitive Development

Omega-3 fatty acids have a positive impact on cognitive development in infants, which is especially important due to the rapid brain development that occurs during pregnancy and the first years after birth.The supplementation of DHA can support improvements in cognitive, motor, and behavioral development. The brain development of infants occurs rapidly, particularly during pregnancy and in the first months after birth. DHA is necessary for neuronal growth, synaptic plasticity, and brain function during this period. Studies have shown that infants receiving DHA supplementation exhibit better performance in cognitive, motor, and behavioral development.

In the last trimester of pregnancy and the initial months of the postnatal period, there is a notable increase in DHA and AA content in the cerebral matter of the human brain (12). Thanks to the placenta's selectively permeable properties, ω-3 fatty acids are transported to the fetus at high rates.. ω-3 fatty acids gather in the eyes, brain, testes, and placenta, and play crucial roles in numerous vital functions in the body from an early stage, including growth and development, gene expression, immune responses, and brain development. ω-3 fatty acids constitute 10-20% of total body lipids, with over 90% of the brain comprising these essential nutrients. Therefore, ω-3 fatty acids are essential for the growth and proliferation of nerve cells during early development (13,14).

Conclusion and Discussion

Healthy nutrition significantly affects both physical and mental development at all stages of life. Foods rich in ω-3 fatty acids, which we consume both during the prenatal and postnatal periods, are crucial for our health. Studies have emphasized that especially during the prenatal period when brain development is rapid, the ω-3 fatty acids the baby receives through the placenta contribute to the baby's neurological development. Therefore, pregnant mothers are advised to consume foods rich in ω-3 fatty acids.

ω-3 fatty acids, particularly DHA, are of critical importance for the brain function and development of infants. Fatty fish such as salmon and sardines, are the richest sources of omega-3. Other sources of omega-3 include flax seeds, purslane, and oily seeds. However, the synthesis of DHA from plant-based omega-3 sources is not as efficient. Therefore, it is recommended that pregnant women consume fatty fish like salmon and sardines 2-3 times a week to ensure sufficient DHA intake. Regarding food safety, it is essential to choose fish with low mercury levels. Products containing omega-3 supplements, especially those derived from cod liver, which has high levels of vitamin A, should be consumed carefully . In conclusion, the consumption of ω-3 fatty acids during pregnancy can positively influence the cognitive development of infants.

REFERENCES

1. SAMUR G. Uzdil Z, Özenoğlu A. Gebelikte çeşitli besin öğeleri tüketiminin bebek sağlığı üzerine etkileri. Balikesir Saglik Bil Derg. 4(2) ; 117-21, 2015.

2. KURATKO C.N. et al. The Relationship of Docosahexaenoic Acid (DHA) with Learning and Behavior in Healthy Children: A Review Nutrients. Jul;5(7):2777–2810.2013

3. Boucher O. et.al. Neurophysiologic and neurobehavioral evidence of beneficial effects of prenatal omega-3 fatty acid intake on memory function at school age Am J Clin Nutr.May;93(5):1025–1037.2011

4. Samur G. Anne sütünün çoklu doymamış yağ asitleri bileşimi ile omega 6/omega 3 yağ asitleri oranı. Beslenme ve Diyet Dergisi 2002;31(1):22-26.

5. Gadoth N. On fish oil and omega-3 supplementation in children: The role of such supplementation on attention and cognitive dysfunction. Brain Dev-JPN 2008;30:309-312

6. Gezer, C., and Samur, G. (2012). Omega-3 yağ asitlerinin bilişsel gelişimdeki rolü. Beslenme ve Diyet Dergisi, 40(1),43-49.

7. Hallahan B, Garland MR. Essential fatty acids and mental health. Br J Psychiat 2005;186:275-277.

8. Gadoth N. On fish oil and omega-3 supplementation in children: the role of such supplementation on attention and cognitive dysfunction. Brain Dev 2008;30(5):309- 312.

9. Innis SM. Human milk: maternal dietary lipids and infant development. Proc Nutr Soc 2007;66(3):397- 404.

10. Stillwell W, Wassall SR. Docosahexaenoic acid: membrane properties of a unique fatty acid. Chem Phys Lipids 2003;126(1):1-27.

11. Çelik F, Demirel ZB (2012) Omega-3 Yağ Asitlerinin Nörolojik ve Görsel Gelişim Üzerindeki Etkileri. Beslenme ve Diyet Dergisi. 40(3): 266-272.

12. Helland IB, Smith L, Saarem K, Saugstad OD, Drevon CA. Maternal supplementation with very-longchain n-3 fatty acids during pregnancy and lactation augments children's IQ at 4 years of age. Pediatrics 2003;111:39-44.

13. Weiser MJ., BUTT CM., MOHAJERİ MH. Docosahexaenoic Acid and Cognition through out the Lifespan. Nutrients. 8(2): 99. Feb.2016

14. Can E.,CÖMERT S., USLU S. ve ark. Uzun Zincirli Çoklu Doymamış Yağ Asitlerinin Yenidoğan Beslenmesindeki Rolü . J Kartal TR XX(2):108- 112.2009.

CHAPTER V

Food of the Future: Laboratory-Produced Meat and Plant-Based Alternatives

Hakan TOĞUÇ[1]

1.Introduction: Projecting Nutritional Trends in the Future

Contemporary food systems confront significant challenges, including the burgeoning global population, environmental constraints, and sustainability imperatives. The United Nations' 2019 projection anticipates the world population reaching 9.7 billion by 2050, suggesting potential inadequacies in existing food production paradigms (Godfray & et al., 2010). Consequently, innovative and non-traditional methodologies are essential for the future of food production.

Traditional livestock farming has faced substantial critique regarding its extensive water and land consumption, greenhouse gas emissions, and animal welfare concerns (Steinfeld & et al., 2006).

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These environmental detriments have heightened interest in alternative protein sources, spotlighting innovative solutions such as laboratory-produced meat and plant-based meat substitutes. Laboratory-produced meat, created through biotechnological cultivation of animal cells, aims to mitigate environmental impact and enhance animal welfare relative to conventional livestock farming (Post, 2012; Bhat & et al., 2017). Conversely, plant-based meat alternatives replicate the texture and flavor of animal meat using plant proteins and other components, offering a sustainable option increasingly favored by consumers attentive to animal welfare (McClements & Grossmann, 2022; Janssen & et al., 2016).

2.The Ascendancy and Potential of Laboratory-Produced Meat

Regarded as a groundbreaking innovation in sustainable food production and ethical nutrition, laboratory-produced meat actualizes Winston Churchill's 1931 vision of lab-grown meat, as described in his article "Fifty Years Hence" (Churchill, 1931). The unveiling of the world's first laboratory-produced hamburger by Dr. Mark Post and his team in 2013 marked a significant advancement in this arena (Post, 2012). This meat is cultivated using cell culture techniques and tissue engineering to develop muscle tissue, integrating stem cell biology with bioreactor systems to produce meat sustainably (Bhat & et al., 2017; Datar & Betti, 2010). Nutritionally akin to conventional meat, laboratory-produced meat may also offer health benefits by potentially mitigating issues associated with traditional meat consumption (Tilman & Clark, 2014).

Laboratory-produced meat exhibits a reduced environmental footprint compared to traditional animal agriculture, presenting a more efficient alternative in terms of water and land utilization, greenhouse gas emissions, and energy consumption (Tuomisto & Teixeira de Mattos, 2011). The evolution of this meat type is driven by advancing technologies and growing consumer interest, with research focusing on food safety, nutritional content, and sensory characteristics (Post, 2012). Commercialization and broader market introduction represent imminent challenges in this field (Stephens & et al., 2018).

3.Plant-Based Meat Alternatives: Diversification and Technological Advancements

Plant-based meat alternatives are anticipated to significantly influence consumer preferences, aligning with the current demands for environmental sustainability and ethical nutrition practices. The genesis of these alternatives traces back to the mid-20th century, coinciding with the burgeoning popularity of vegetarian and vegan diets. Recent advancements, particularly in technology and research and development (R&D), have remarkably enhanced the quality and variety of these products (Gregory, 2017). These developments have enabled plant-based products to closely resemble traditional meat in texture, flavor, and nutritional value, presenting compelling alternatives.

The primary constituents of plant-based meat substitutes include vegetable proteins like soy, pea, and wheat. These proteins undergo various processing techniques to imitate the texture and flavor characteristics of animal meat. Techniques such as extrusion, which employs high pressure and heat, transform vegetable proteins into fibrous, meat-like textures. Additional methods like protein texturing and fermentation further refine the texture and flavor profiles to resemble meat more closely (Kumar & et al., 2017). These alternatives typically offer a high protein content with generally lower levels of saturated fat compared to animal meat. Their enrichment with fiber, vitamins, and minerals enhances their nutritional profile, positioning them as healthful options. Furthermore, the availability of allergen-free or low-gluten variants caters to diverse dietary requirements (Sabaté & Soret, 2014).

Amidst growing consumer consciousness regarding environmental, health, and animal welfare issues, plant-based meat alternatives have carved a substantial niche in the global food market, with prospects for continued expansion (Bryant & Barnett, 2018). This escalating demand is propelling food manufacturers to innovate and diversify in the realm of plant-based meat substitutes. The trajectory of these products is being shaped by evolving technologies and heightened consumer awareness, presenting a more sustainable option relative to traditional animal agriculture. This translates to a reduced environmental footprint in terms of water and land usage, greenhouse gas emissions, and overall energy consumption. The safety and health benefits associated with these crops suggest their significant role in future food systems (Eshel & et al., 2019).

Catering not only to vegetarian and vegan diets but also appealing to a broader demographic seeking to reduce meat consumption, plant-based meat alternatives are integral to the sustainability of contemporary food systems. They aim to offer innovative solutions to meet a spectrum of nutritional needs, thereby contributing to the diversification and resilience of modern food paradigms (Bryant & Barnett, 2018).

4.Nutritional and Health Implications of Novel Food Sources

The exploration of the health impacts of laboratory-produced meat and plant-based meat alternatives is a burgeoning area in contemporary nutritional science. Laboratory-produced meat offers the potential to replicate the nutritional profile of conventional meat while optimizing key aspects such as the fatty acid composition, and the levels of vitamins and minerals. This bioengineering approach can potentially reduce saturated fat levels while augmenting beneficial fats like omega-3 fatty acids, thereby potentially diminishing the risk of cardiovascular diseases and certain chronic conditions (Bhat & et al., 2017). Moreover, the absence of antibiotic residues, hormones, and pathogens, commonly associated with conventional meat, positions laboratory-produced meat as a safer alternative in terms of food safety (Stephens & et al., 2018).

Plant-based meat alternatives are lauded for their high fiber content and reduced saturated fat levels. These characteristics are linked to a decreased risk of chronic diseases, including cardiovascular disease, type 2 diabetes, and certain cancers (McClements & Grossmann, 2022). However, it is crucial to recognize that these alternatives may fall short in delivering optimal bioavailability of certain key nutrients, such as vitamin B12, iron, and zinc (Sabaté & Soret, 2014).

Both laboratory-produced meat and plant-based meat alternatives are posited to contribute significantly to public health. These novel food sources may provide solutions to health issues attributed to traditional meat consumption, such as antibiotic resistance and zoonotic diseases. Furthermore, they could play a pivotal role in chronic disease prevention when integrated into a balanced and healthy diet (Tilman & Clark, 2014). The increasing adoption of these alternatives could instigate shifts in nutrition policies and public health strategies. Advocating for and supporting these products might foster the adoption of sustainable and healthy eating practices. Nevertheless, it is imperative to advocate for further research to comprehensively understand the health impacts of these innovative food sources (WHO, 2019). Particular emphasis should be placed on conducting extensive research into their long-term health effects, the diversity of nutrient intake, and their overall influence on nutritional balance.

5.Sustainability and Environmental Implications of Emerging Food Technologies

The emergence of laboratory-produced meat and plant-based meat alternatives marks a pivotal shift in sustainability and environmental stewardship. Laboratory meat production emerges as a sustainable alternative to traditional animal agriculture, offering the potential to drastically reduce greenhouse gas emissions, water usage, and land requirements (Tuomisto & Teixeira de Mattos, 2011). This technology negates the need for expansive land and intensive water resources typically associated with conventional animal rearing, positioning it as a significant contributor to climate change mitigation efforts (Post, 2012).

Similarly, plant-based meat alternatives exhibit a reduced environmental footprint in comparison to traditional animal meat production. The utilization of plant proteins as a base is associated with decreased soil erosion, water pollution, and greenhouse gas emissions. Additionally, the production processes of these alternatives are generally more energy-efficient and are considered conducive to the adoption of renewable energy sources (Sabaté & Soret, 201; Eshel & et al., 2019).

Both laboratory-produced meat and plant-based meat alternatives are posited to substantially enhance the sustainability of global food systems. These novel food sources could offer viable solutions to pressing issues such as food security and malnutrition, potentially leading to more equitable and accessible food systems. Their production is also thought to promote more efficient utilization of food resources and conservation of natural resources (Godfray & et al., 2010).

However, a thorough assessment of the environmental impacts of these innovative food sources remains necessary. The scaling up of production processes poses economic and technological challenges, and shifting consumer behavior is essential for their widespread acceptance and integration into diets (Stephens & et al., 2018). Future strategies should focus on developing innovative approaches and policies to minimize environmental impacts and maximize the sustainability potential of these food sources. Laboratory-produced meat and plant-based meat alternatives not only transform food production and consumption patterns but also have profound ethical and social implications. These developments are expected to play a critical role in steering towards a sustainable and equitable global food system (Post, 2012).

6.Ethical and Social Considerations in Novel Food Technologies

The burgeoning utilization of laboratory-produced meat and plant-based meat alternatives introduces significant ethical and social considerations. Laboratory meat production is heralded for its potential to substantially improve animal welfare, mitigating ethical concerns inherent in traditional animal agriculture. This technology is anticipated to circumvent ethical dilemmas associated with animal rearing and slaughtering practices (Hopkins & Dacey, 2008). Similarly, plant-based meat alternatives are regarded as ethically favorable, offering a means of production devoid of animal harm. These alternatives might appeal particularly to consumers with strong convictions about animal welfare, potentially elevating ethical standards in food production.

The widespread acceptance of these new food sources is intricately linked to consumer perceptions and cultural attitudes. There exists a degree of skepticism, particularly concerning the perceived naturalness and safety of laboratory-produced meat, which could influence public acceptance (Bryant & Barnett, 2018). Effective consumer education and transparent communication are pivotal in fostering public acceptance of these innovations.

The integration of laboratory-produced meat and plant-based meat alternatives into mainstream diets could significantly alter traditional food cultures and eating habits. This shift reflects an increasing demand for sustainable and ethical food choices and evolving social norms around conventional meat consumption (Janssen & et al., 2016). The implications of these products on food safety, as well as their impact on local economies, constitute critical considerations at the socio-economic level.

The ethical and social aspects of laboratory-produced meat and plant-based meat alternatives are crucial factors likely to influence future food policies and regulations. A holistic policy approach is necessary to align these novel food sources with broader objectives of social welfare, environmental sustainability, and economic development. Additionally, interdisciplinary research is imperative to thoroughly assess the ethical and social impacts of these emerging technologies (Bryant & Barnett, 2018).

7.Gelişen Gıda Teknolojilerinin Ekonomik Etkileri ve Pazar Dinamikleri

Laboratuvar ortamında üretilen et ve bitki bazlı et alternatiflerinin piyasaya sürülmesi, ekonomik perspektifler ve pazar dinamiklerinde önemli dönüşümlere sebep olmaktadır. Çevresel, sağlık ve etik endişelerle bu yeni gıda kaynaklarına olan küresel talebin artması, yakın gelecekte pazarın büyük ölçüde genişleyeceğini göstermektedir (GFI, 2019). Özellikle bitki bazlı et alternatifleri, geniş bir tüketici kitlesine ulaşarak hızla büyüyen bir sektör haline gelmiştir (FAIRR Initiative, 2019). Bu büyüme, hem yeni kurulan start-up'lar hem de köklü gıda şirketlerinin bu alanlara yaptığı yatırımlarla desteklenmektedir. Bu yatırımlar, teknolojik ilerlemeleri hızlandırmakla kalmayıp, üretim maliyetlerini düşürmeyi de hedeflemektedir. Bunun yanı sıra, geleneksel et üreticileri de bu yeni pazar segmentine girerek ürün çeşitliliklerini artırmaktadır (Kearney, 2019).

Tüketici tercihleri ve davranışları, laboratuvar ortamında üretilen et ve bitki bazlı et alternatiflerinin pazar dinamiklerini önemli ölçüde etkilemektedir. Çevresel ve sağlık konularındaki artan farkındalık, tüketicileri bu yenilikçi gıda kaynaklarına yönlendirmektedir. Bu ürünlerin lezzeti, fiyatı ve erişilebilirliği de tüketici kabulü ve pazara nüfuz etme açısından önemli faktörler arasında yer almaktadır (Nielsen, 2019). Bu ürünlerin pazarı, sürekli değişen tüketici talepleri, teknolojik gelişmeler ve düzenleyici çerçeveler tarafından şekillendirilmektedir.

Gelecek yıllarda, bu ürünlerin daha maliyet etkin ve geniş çapta erişilebilir olması beklenmektedir. Bununla birlikte, bu yeni gıda kaynaklarının pazar payının, geleneksel et ürünleriyle nasıl rekabet edeceği, hem ekonomik hem de toplumsal faktörlere bağlı olacaktır. Bu durum, gıda endüstrisinde bir ekonomik dönüşümü temsil etmekte ve pazar dinamiklerini yeniden şekillendirmektedir. Laboratuvar ortamında üretilen et ve bitki bazlı et alternatiflerinin, sürdürülebilir ve yenilikçi bir gıda ekonomisinin önemli bileşenleri haline gelmesi beklenmektedir (McKinsey & Company, 2020).

8.Legal Frameworks and Food Safety Protocols for Novel Food Sources

The introduction of laboratory-produced meat and plant-based meat alternatives necessitates a reevaluation and enhancement of existing food safety and regulatory standards. Given their unique nature, these innovative food products transcend the scope of current regulations and standards that govern conventional food items. There is a pressing need for new regulatory frameworks that address the safety, labeling, and marketing of these products. Therefore, key regulatory bodies such as the European Food Safety Authority (EFSA) and the United States Food and Drug Administration (FDA) are poised to play instrumental roles in establishing safety and labeling standards for these novel food sources (FDA, 2019).

Each phase of the production process, including raw material procurement, production methodology, packaging, and distribution, must be meticulously regulated. Ensuring the safety of these products mandates comprehensive risk analyses and stringent quality control measures to mitigate risks of foodborne illnesses and contamination (ISO, 2020). There is notable international variability in the regulation of laboratory-produced meat and plant-based meat alternatives, with significant discrepancies in legal frameworks and standards between regions like the European Union and the United States. Such differences may pose challenges for international trade and market access (WTO, 2018).

Furthermore, the labeling of these products is critical to enable consumers to make informed choices. Labels should transparently disclose information about ingredients, nutritional content, and production processes. Additionally, adherence to regulatory guidelines is essential to prevent consumer deception and to clearly differentiate these products from traditional offerings. This scenario underscores the need for novel approaches and standards in food safety and regulatory domains. The safe, ethical, and transparent production and consumption of these emerging food sources can be achieved through robust legal frameworks and standards (EU Commission, 2021).

9.Future Prospects: Navigating Challenges and Harnessing Opportunities in Food Technology

The advent of laboratory-produced meat and plant-based meat alternatives heralds a period of both challenges and opportunities within the food industry. The production of laboratory meat and the advancement of plant-based meat substitutes necessitate cutting-edge technologies and sustained research and development (R&D) endeavors. Breakthroughs in biotechnology, tissue engineering, and food processing technologies are crucial for enhancing the quality and economic viability of these products (Post, 2013; Bhat & et al., 2017). Future research should aim to enhance the nutritional value of these products while minimizing their environmental footprint (Specht & et al., 2018).

The sustainability aspect of these products is paramount, especially in reducing the environmental burden of food production. However, the large-scale production and consumption of these products must be evaluated in the context of natural resource utilization and energy consumption (Tuomisto & Teixeira de Mattos, 2011; Eshel & et al., 2019).

Consumer acceptance of these innovative food sources hinges on perceptions and market dynamics. Educational initiatives and awareness campaigns are vital in fostering acceptance (Bryant & Barnett, 2018; Janssen & et al., 2016). The evolution of the market for these products will be influenced by factors such as pricing, taste, and accessibility (Nielsen, 2019).

Regulating and ethically framing these new food sources present significant legal and ethical challenges. Food safety standards, labeling practices, and animal welfare considerations ought to underpin legal frameworks in this sector (FDA, 2019). Additionally, the social and cultural implications of these products should be considered by policymakers and regulatory bodies (WTO, 2018).

Laboratory-produced meat and plant-based meat alternatives have the potential to address global challenges related to food security and malnutrition. By making food production more sustainable and accessible, these new sources could play a crucial role in meeting the burgeoning food demands of the global population (Godfray & et al., 2010). Progress in this field necessitates collaboration and investment between the private sector and government entities. Such partnerships are essential for the commercialization, scaling, and widespread accessibility of these novel food sources (Kearney, 2019).

References

Kearney AT. (2019). How Will Cultured Meat and Meat Alternatives Disrupt the Agricultural and Food Industry?

https://european-biotechnology.com/up-to-date/latest-news/news/report-how-will-meat-alternatives-disrupt-the-agricultural-and-food-industry.html. Access date: 07.12.2023

Bhat, Z.F., Kumar, S., & Fayaz, H. (2017). In Vitro Cultured Meat—a Future Harvest. *Journal of Integrative Agriculture*, 16(4), 756-766.

Bryant, C., & Barnett, J. (2018). Consumer Acceptance of Cultured Meat: A Systematic Review. *Meat Science*, 143, 8-17.

Churchill, W. (1931). Fifty Years Hence. *Strand Magazine*.

https://winstonchurchill.org/wp-content/uploads/2008/06/krummenackeredithuxleywsc.pdf

Access date: 07.12.2023

Datar, I., & Betti, M. (2010). Possibilities for an In Vitro Meat Production System. *Innovative Food Science & Emerging Technologies*, 11(1), 13-22.

Eshel, G., Shepon, A., Makov, T., & Milo, R. (2019). Land, Irrigation Water, Greenhouse Gas, and Reactive Nitrogen Burdens of Meat, Eggs, and Dairy Production in the United States. *Proceedings of the National Academy of Sciences*, 111(33), 11996-12001.

EU Commission. (2021). EU Food Labeling Regulations.

https://food.ec.europa.eu/safety/labelling-and-nutrition/food-information-consumers-legislation_en. Access date: 07.12.2023

FAIRR Initiative. (2019). Plant-based Profits: Investment Risks & Opportunities in Sustainable Food Systems.

https://www.fairr.org/resources/reports/plant-based-profits-investment-risks-opportunities-sustainable-food-systems. Access date: 07.12.2023

FDA. (2019). Regulation of Cultured Meat.

https://www.fda.gov/food/food-ingredients-packaging/human-food-made-cultured-animal-cells. Access date: 07.12.2023

Food and Agriculture Organization of the United Nations and World Health Organization. (2019). Sustainable Healthy Diets.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M., & Toulmin, C. (2010). Food Security: The Challenge of Feeding 9 Billion People. *Science*, 327(5967), 812-818.

Good Food Institute. (2019). Plant-based Meat Market Report.

https://gfi.org/marketresearch/ Access date: 07.12.2023

Gregory, A. (2017). Plant-based Meats Gaining Traction. *Food Technology*, 71(1), 38-43.

Hopkins, P.D., & Dacey, A. (2008). Vegetarian Meat: Could Technology Save Animals and Satisfy Meat Eaters? *Journal of Agricultural and Environmental Ethics*, 21(6), 579-596.

ISO 22000. Food safety management.

https://www.iso.org/iso-22000-food-safety-management.html. Access date: 07.12.2023

Janssen, M., Busch, C., Rödiger, M., & Hamm, U. (2016). Motives of Consumers Following a Vegan Diet and Their Attitudes Towards Animal Agriculture. *Appetite*, 105, 643-651.

Kumar, P., Chatli, M.K., Mehta, N., Singh, P., Malav, O.P., & Verma, A.K. (2017). Meat Analogues: Health Promising Sustainable Meat Substitutes. *Critical Reviews in Food Science and Nutrition*, 57(5), 923-932.

McClements, D.J., & Grossmann, L. (2022). The Rise of Plant-Based Foods. *In Next-Generation Plant-based Foods* (pp. 1–21).

McKinsey & Company. (2020). The Future of Meat: A McKinsey Report.

Nielsen. (2018). The Plant-based Protein Opportunity.

Post, M.J. (2012). Cultured Meat from Stem Cells: Challenges and Prospects. *Meat Science*, 92(3), 297-301.

Post, M.J. (2013). The First Lab-Grown Hamburger. *The Guardian.*

https://www.theguardian.com/science/2013/aug/05/first-hamburger-lab-grown-meat-press-conference. Access date: 07.12.2023

Sabaté, J., & Soret, S. (2014). Sustainability of Plant-based Diets: Back to the Future. *The American Journal of Clinical Nutrition*, 100(Supplement 1), 476S-482S.

Specht, E.A., Welch, D.R., Clayton, E.M.R., & Lagally, C.D. (2018). Opportunities for Applying Biomedical Production and Manufacturing Methods to the Development of the Clean Meat Industry. *Biochemical Engineering Journal*, 132, 161-168.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., & De Haan, C. (2006). Livestock's Long Shadow: Environmental Issues and Options. *FAO*.

Stephens, N., Di Silvio, L., Dunsford, I., Ellis, M., Sexton, A., & Chang, D. (2018). Bringing Cultured Meat to Market: Technical, Socio-Political, and Regulatory Challenges in Cellular Agriculture. *Trends in Food Science & Technology*, 78, 155-166.

Tilman, D., & Clark, M. (2014). Global Diets Link Environmental Sustainability and Human Health. *Nature*, 515, 518-522.

Tuomisto, H.L., & Teixeira de Mattos, M.J. (2011). Environmental Impacts of Cultured Meat Production. *Environmental Science & Technology*, 45(14), 6117-6123.

WTO. (2018). International Trade and Food Safety Standards.

https://www.wto.org/english/res_e/publications_e/world_trade_report18_e.pdf. Access date: 07.12.2023

CHAPTER VI

The Health Effects of Polyphenols and Mental Health

Mukaddes KILIÇ BAYRAKTAR[1]
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Introduction

Secondary metabolites called polyphenols are frequently present in plants. These substances are plentiful micronutrients in our diet and are also known as phytochemicals, which are compounds produced by plants. Fruits, vegetables, cereals, tea, coffee, wine, and different plant-based foods, and beverages are the primary nutritional sources of phenolic components (Gharras, 2009). In developed countries, the prevalence of noncommunicable diseases, including cardiovascular disease, cancer, diabetes, and obesity, has increased significantly in recent years. Therefore,

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bioactive compounds, which play a crucial role in disease prevention, are gaining importance day by day (Pérez-Gregorio et al., 2020). Polyphenols, one of the essential bioactive compounds, are considered as nutraceuticals with the potential to prevent excessive formation of oxidant species in normal cells as antioxidants and to halt or reverse diseases associated with oxidative stress (Piccolella et al., 2019). Polyphenols are the best sources of bioactive substances that provide protection from degenerative diseases, cancer, and cardiovascular disease (Gharras, 2009).

Dietary habits of individuals often interact with psychosocial factors. Stress, emotional state, lifestyle, and social environment can influence dietary choices, and dietary habits can influence the risk of depression through neurochemical, inflammatory, microbiotic and psychosocial factors. Recent epidemiologic evidence suggests that consuming specific plant-based foods and drinks may be linked to a decreased risk of developing depression. Polyphenols may benefit mental health, including depression and anxiety, according to recent studies (Molendijk et al., 2018). The antioxidant characteristics of polyphenols may shield neural cells from the deleterious impacts of free radicals. This protective impact slows down the aging process of nerve cells, which may help preserve cognitive skills. Moreover, the neuroprotective properties of polyphenols may retard the advancement of neurodegenerative diseases such as Alzheimer's and Parkinson's. When the role of polyphenols in combating depression was examined, it was found that thanks to their anti-inflammatory properties, by reducing inflammation in the brain, polyphenolic compounds may alleviate symptoms of depression, reduce anxiety levels and support stress coping mechanisms (Pandey & Rizvi, 2009; Rendeiro, Rhodes & Spencer, 2015). In addition, the positive effects of some polyphenols on neurotransmission such as serotonin and dopamine may have a regulatory effect on the neurochemical mechanisms of depression (Kulkarni, Bhutani & Bishnoi, 2008). This study will examine the functional health effects of polyphenols, the relationship between depression and nutrition, and specifically the effects of consuming foods high in polyphenol content on mental health.

Definition and Classification of Polyphenols

Polyphenols are micronutrients that include one or more hydroxyl groups and at least one aromatic ring (Del Rio et al., 2013). These compounds are produced as a regular part of a plant's development and in reaction to various conditions, including stress and UV radiation exposure (Haminiuk et al., 2012). So far, more than 8000 different structures of polyphenolic compounds have been detected. These chemicals are divided into four groups based on the amount of phenol rings they contain and the structural elements that connect these rings: lignans, flavonoids, stilbenes, and phenolic acids (Manach et al., 2004). The primary dietary sources of polyphenols and their overall classification are shown in Table 1.

Tablo 1. Polyphenol subtypes and primary dietary sources (Clarke & Currie, 2009; Dodd et al., 2013)

Polyphenol Type	Subclasses	Example	Dietary Sources
Phenolic Acid	Hydroxycinnamic Acid	p-coumaric acid, caffeic acid, chlorogenic acid, ferulic acid	Orange, avocado, black grapes, pineapple, apple, broccoli, tomatoes, strawberries, coffee, thyme, apricot, cereal grains
	Hydroxybenzoic Acid	Gallic acid, vanillic acid, syringic acid	Avocado, strawberries, banana, blueberries, blackberries, raspberries, cloves, black tea, green tea
Flavonoids	Flavonols	Quercetin, kaempferol	Black tea, grapes, apple, red wine, spinach, blackberries
	Flavanones	Hesperetin, naringenin, eriodictyol	Grapefruit, orange, lemon, tomatoes
	Flavan-3-ols	Epicatechin, catechin, epicatechin gallate, epicatechin-3-gallate	Green tea, cherries, red wine, grapes, cocoa
	Flavones	Luteolin, apigenin	Pineapple, red pepper, lemon, cantaloupe
	Anthocyanidins	Malvidin, cyanidin, pelargonidin, delphinidin	Grapes, blackberries, strawberries, apple, cherry, plum
	Isoflavonoids	Genistein, daidzein, glycitin	Soybeans, legumes
Stilbenes	__	Resveratrol	Red wine, grapes, strawberries
Lignans	__	Secoisolariciresinol, matairesinol	Flaxseed, tangerine, cantaloupe, olive oil, garlic

Functional Health Effects of Polyphenols

The beneficial properties of plant derivatives and preparations, including those with high polyphenol content such as olives, grapes, green tea, and leaf extracts, have been scientifically investigated in recent years. These investigations have concentrated on the potential health benefits of polyphenols, exposing their anti-inflammatory, antimicrobial, antioxidant, antidepressant, and antihypertensive characteristics. Additionally, the development of novel medications to treat a range of chronic illnesses, including cancer, cardiovascular disease, type 2 diabetes, and age-related neurodegenerative diseases, can make use of polyphenols (Figure 1) (Leri et al., 2020; Toric et al., 2019).

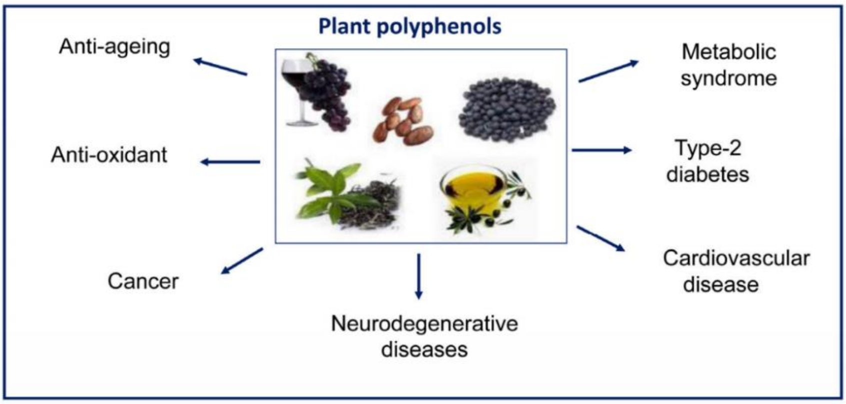

Figure 1. Plant polyphenols and their potential to lower the incidence of degenerative and metabolic illnesses (Leri et al., 2020)

Anti-Cancer Effect

Research has demonstrated that dietary polyphenols can be used as a treatment for several diseases, such as cancer (Ahmad et al., 2022). Polyphenols mostly have protective effects on human cancer cell lines, reducing the number or size of tumours (Yang et al., 2001). These effects have been observed in a variety of sites, including the mouth, stomach, duodenum, colon, liver, lungs, breast, and skin.

Although polyphenols including ellagic acid, resveratrol, curcumin, isoflavones, lignans, flavanones, and quercetin have been shown to have distinct modes of action, they all show protective effects in some animals (Pandey & Rizvi, 2009).

Results from cell line investigations are also supported by evidence from epidemiological studies. Anthocyanidins, flavones, and total flavonoids have been linked to a lower incidence of stomach cancer, especially in women, according to a Korean study (Woo et al., 2014). Consuming lignans and flavonoids, especially flavones and proanthocyanidins, may reduce the risk of colorectal cancer, according to case-control research conducted in Spain (Zamora-Ros et al., 2013).

Anti-Diabetic Effect

One of the most important public health problems facing the globe today is diabetes. Globally, there were 422 million diabetes patients according to the World Health Organization (WHO) in 2014; by 2030, there are projected to be 592 million diabetics (Wild et al., 2004). Preventing the development of diabetes is less expensive than treating its complications. Recent research has shown that eating foods high in polyphenols can help prevent and manage diabetes (Thomas & Pfeiffer, 2012).

According to research, polyphenols can block the absorption of glucose by the intestines or peripheral tissues, which can have anti-diabetic effects (Pandey & Rizvi, 2009). They also exhibit anti-inflammatory and antioxidant properties, which shield cells from the damaging effects of glucose (Xiao & Hogger, 2014).

A study that lasted more than 20 years and was carried out in the US revealed a link between diabetes and flavonoid intake. It has been demonstrated that consuming more anthocyanins lowers the chance of getting type 2 diabetes (Wedick et al., 2012). In a study investigating the anti-diabetic effects of resveratrol, it was found that resveratrol administration in diabetic rats restored glucose homeostasis and improved insulin sensitivity. It was also observed to significantly improve kidney function and oxidative stress in rats (Milne et al., 2007; Wedick et al., 2012).

The effects of quercetin on inflammatory biomarkers and cardiovascular risk factors in women with type 2 diabetes were studied in a randomized clinical trial. Participants were given 500 mg capsules of quercetin, and after 10 weeks, serum concentrations of tumor necrosis factor-alpha (TNF-) and interleukin-6 (IL-6) were shown to be considerably lower. Additionally, systolic blood pressure was significantly reduced (Zahedi et al., 2013).

Protective Effect Against Cardiovascular Diseases

Atherosclerosis is a long-term inflammatory condition that appears in medium-sized artery lesion-prone regions. It might take a long time for atherosclerotic lesions to manifest symptoms and turn into an active state that results in pathological conditions like sudden cardiac death or acute myocardial infarction (Vita, 2005). Low-density lipoprotein (LDL) oxidation is an important process in the development of atherosclerosis, and polyphenols are potent inhibitors of this process (Woo et al., 2014). Additional ways that polyphenols may protect against cardiovascular diseases (CVD) include their anti-inflammatory, antiplatelet, and antioxidant properties. Additionally, they might improve endothelial function and increase HDL (García-Lafuente et al., 2009).

Catechins are also known to assist in preventing CVD. It has been demonstrated that green tea catechins prevent smooth muscle cells from invading and growing in artery walls, thereby delaying the development of atheromatous lesions. Furthermore, they might have antithrombotic qualities by inhibiting platelet aggregation (Maeda et al., 2003). Researchers found that drinking about 450 milliliters of black tea two hours after ingestion enhanced arterial dilatation, and that consuming 240 milliliters of red wine for thirty days prevented endothelial dysfunction brought on by a diet heavy in fat (Duffy et al., 2001).

Other Health Effects

Age-related sickness and mortality are increased due to the accumulation of several harmful changes in cells and tissues throughout time. The free radical/oxidative stress theory is one of the most widely recognized explanations for the aging process among other theories. There is always some degree of oxidative damage, even in normal circumstances, but as we age, antioxidant and repair mechanisms become less effective, accelerating the rate of damage (Pandey & Rizvi, 2009). Research has shown that fruits and vegetables include antioxidant-rich, anti-inflammatory polyphenolic substances that can act as anti-aging agents (Joseph, Shukitt-Hale & Casadesus, 2005).

Spinach, strawberries, and blueberries, high in flavonoids, have been found to exhibit high antioxidant activity. Dietary supplements containing extracts of spinach, strawberries, or blueberries (for 8 weeks) have been shown to be successful in restoring age-related deficits in the brain and behavior of old rats (Shukitt-Hale, Lau & Josep, 2008). Another study found that tea catechins have potent anti-aging properties, and that drinking green tea high in catechins may delay the onset of aging (Maurya & Rizvi, 2009).

Another functional health effect of polyphenols is on the intestinal microbiota. It has been noted that by suppressing specific bacterial groups, polyphenols can change the makeup of the intestinal microbiota and foster the growth of beneficial bacteria (Cardona et al., 2013). Yamakoshi et al. showed that giving healthy adults a proanthocyanidin-rich grape seed extract for two weeks dramatically enhanced the amount of bifidobacteria (Yamakoshi et al., 2001). Additionally, recent studies show that foods high in flavan-3-ol, like chocolate, green tea, and grape or grape seed extracts, can alter the intestinal microbiota in vivo and boost the number of helpful bacteria, like Lactobacillus spp (Tzounis et al., 2008, 2011).

Nutrition and Depression: A Correlation

Depression, along with psychiatric disorders such as anxiety and stress, affects many people worldwide. Depression is a health issue that negatively impacts both the mental and physical aspects of human life, leading to impaired interpersonal relationships, economic and professional losses, decreased quality of life, and even suicidal tendencies (Akar, Altun & Anber, 2021). Studies on the epidemiology of depression generally suggest that the frequency and prevalence of depression are higher in women than in men (Yalvaç, 2012). Among the reasons for this difference are hormonal and genetic variations, the higher incidence of thyroid diseases in women, physiological processes such as the menstrual cycle, social and family pressures experienced more by women, and psychosocial stress created by roles assigned, such as household chores and childbearing (Akar, Altun & Anber, 2021).

According to recent reports, it is predicted that more than 300 million people worldwide live with depression, and anxiety disorders affect over 260 million individuals (Friedrich, 2017). Additionally, while depression and anxiety may not be the primary causes, they are often associated with other mental conditions and non-communicable diseases such as cardiovascular disease, dementia, and cancer (Clarke & Currie, 2009).

As the prevalence of neurodegenerative and psychiatric disorders continues to rise, there is an increasing demand for unpredictable treatment methods and their associated costs. The American Psychiatric Association (APA) recommends pharmacotherapy, psychotherapy, or combined treatments for patients with Major Depressive Disorder (MDD) in the "Practice Guideline for the Treatment of Patients with Major Depressive Disorder." However, there are restrictions with medication and/or psychotherapy. Apart from the financial strain, the adverse effects of antidepressants present significant issues. Antidepressant side effects that are frequently experienced include nausea, increased appetite and weight gain, erectile dysfunction and reduced orgasm, sleeplessness and exhaustion, and insomnia. Furthermore, new research suggests that antidepressants might even promote suicidal thoughts. These challenges have prompted researchers to seek alternative methods for preventing and treating MDD. Consuming a suitable diet is among the most appealing concepts (Huang et al., 2019).

Research on the relationship between nutrition and mental health has been conducted through many systematic reviews and meta-analyses. As per the analysis of four cohorts and nine cross-sectional studies, there is a correlation between a lower incidence of depression and a "healthy diet" that is rich in fruits, vegetables, seafood, and whole grains (Lai et al., 2014). A second meta-analysis comprised eight cohort studies and one case-control study and found that eating a Mediterranean diet was associated with a decreased incidence of depression (Psaltopoulou et al., 2013). A comprehensive review that included twenty-one cross-sectional and twenty-longitudinal research has produced compelling evidence recently that the Mediterranean diet may protect against depression (Lassale et al., 2018).

While dietary changes can contribute to improving depressive symptoms, they can also worsen the depressive condition. According to studies in this area, eating a diet high in "processed food" is associated with an increased risk of depression (Khosravi et al., 2020). According to a six-year Spanish cohort research, those who consumed large amounts of fast food (hamburgers, sausages, and pizza) and processed bakery goods (croissants, cakes, and pastries) were up to 48% more likely to experience depression than those who did not (Sánchez-Villegas et al., 2012). According to a cross-sectional study done in Australia, people who experience extreme anxiety tend to eat fewer fruits and vegetables, have lower adherence to healthy eating habits, and prefer high energy density but low nutritional value foods (Forsyth, Williams & Deane, 2012). Additionally, some opinions contend that eating too many high-sugar foods may raise one's risk of developing anxiety and depression by causing blood sugar levels to rise and fall quickly on repeat. However, as there is probably a bidirectional relationship between depression and carbohydrate consumption, there is no causal evidence to support the relationships found in cross-sectional studies (Gangwisch et al., 2015; Salari-Moghaddam et al., 2019).

Polyphenols and Mental Health

Research suggests that dietary quality may have an impact on the onset of depression. According to recent epidemiological research, eating and drinking specific plant-based foods and drinks, like coffee, tea, fruits, and vegetables, may reduce the risk of developing depression (Molendijk et al., 2018). These food groups have one thing in common: they're high in polyphenols, which are substances with a variety of anti-inflammatory and antioxidant effects (Godos et al., 2018). Dietary polyphenols have been associated with several favorable health outcomes, including a decreased risk of mortality, cancer, and heart disease. Furthermore, eating different classes of polyphenols has been linked to a higher adherence to dietary recommendations that are thought to be healthy, such the Mediterranean diet (Grosso et al., 2017; Wang et al., 2014). The ability of polyphenols to influence multiple mechanisms involved in the pathophysiology of depression is supported by both in vitro and in vivo studies. In these studies, several dietary polyphenols, including lignans, phenolic acids and flavonoids, were found to have anti-neuroinflammatory effects, suppress neuronal apoptosis and promote adult neurogenesis (Rendeiro, Rhodes & Spencer, 2015).

In vivo findings from depression models induced by unpredictable stress reveal a strong connection between the occurrence of depression and increased activities and levels of Monoamine Oxidase (MAO) and malondialdehyde (MDA) in the brain, as well as decreased levels of glutathione, glutathione reductase, and glutathione peroxidase activities (Mao et al., 2009). Several studies have suggested that curcumin's antidepressant action interacts with monoamine oxidase (MAO), an enzyme that inhibits the metabolism of monoamines and results in the inactivation of monoaminergic neurotransmitters like serotonin, dopamine, and norepinephrine (Heninger, Delgado & Charney, 1996). Curcumin and piperine, two black pepper alkaloids, combined suppressed the activity of MAO enzymes in a mouse experiment. This prevented the breakdown of monoaminergic neurotransmitters and increased serotonin and dopamine levels (Kulkarni, Bhutani & Bishnoi, 2008).

One of the most potent dietary antioxidants is the green tea polyphenol epigallocatechin gallate (EGCG), which has a potent protective effect against cellular damage caused by reactive oxygen species (ROS). EGCG has been shown to have neuroprotective effects in both *in vitro* and *in vivo* studies. In cellular and animal models of neurodegenerative disorders such as Parkinson's, for instance, EGCG has been shown to reduce neuronal loss caused by oxidative stress (Vignes et al., 2006). In a research study examining green tea's potential antidepressant properties, mice were given green tea polyphenols orally for seven days, and their depressive symptoms were evaluated using the forced swimming test (FST) and tail suspension test (TST). Green tea polyphenols were found to significantly decrease in immobility in both FST and TST, lowering serum corticosterone and adrenocorticotropic hormone (ACTH) levels, indicating antidepressant-like effects (Zhu et al., 2012).

In an *in vivo* investigation into parsley polyphenols' potential to help treat anxiety and depression, a phenolic extract obtained from parsley plants was administered to experimental group mice at doses of 50 and 100 mg/kg for 21 days. The control group mice were treated with classical antidepressant drugs such as bromazepam and paroxetine. Forced swimming was used to measure antidepressant activity, while open field and light-dark box tests were used to measure anxiolytic activity. The results showed that the phenolic extract, particularly at a dose of 100 mg/kg, exhibited strong anxiolytic and antidepressant-like effects, reducing depressive and anxiolytic behaviour more effectively than paroxetine and bromazepam (Es-safi et al., 2021).

Human studies also show effects like those observed in animal studies. For instance, a study conducted with elderly Asian participants found that those who consumed curry more frequently had a more advanced cognitive performance compared to people who don't often eat curry (Ng et al., 2006). Similarly, a study conducted in Japan revealed that people who drank green tea frequently had a lower risk of cognitive deterioration than those who drank green tea infrequently. (Niu et al., 2009). In China, 716 adults 55 years of age and older participated in a study that looked at the connection between tea drinking patterns and cognitive abilities. The individuals self-reported their tea drinking frequency. A battery of neuropsychological tests focusing on attention, memory, and information processing, as well as the Mini-Mental State Examination, were used to assess cognitive function. Consequently, older adults who drank a lot of tea scored better on cognitive performance tests (Feng et al., 2010).

In a randomized controlled experiment, participants with mild hypertension between the ages of 40 and 65 were divided into two groups to investigate the impact of a high-polyphenol diet on mental health. A high-polyphenol diet consisting of one apple, one orange, half a grapefruit, or a glass (150 mL) of fruit juice, three tablespoons of vegetables, and 70% cocoa dark chocolate was given to the experimental group. The control group was given a low-polyphenol diet that consisted of fewer fruits and vegetables (2 servings per day) and no dark chocolate. After an 8-week intervention, the high-polyphenol diet group had a 66.6% decrease in Beck Depression Inventory-II (BDI-II) scores (Kontogianni et al., 2020).

Conclusion

Several recent studies have provided evidence supporting the idea that diet quality can influence the onset of depression. Unhealthy eating habits have been associated with negative mood and susceptibility to depression, while the consumption of some plant-based foods and drinks, like tea, coffee, fruits, and vegetables, has been connected to happier moods and found to be negatively correlated with feelings of stress and depression. Research has indicated that the Mediterranean diet, with its high polyphenol content, is effective in protecting against the risk of depression. However, to fully understand which compounds and subtypes of polyphenols are effective in influencing depressive symptoms, longitudinal studies and randomized controlled trials conducted on a larger and more diverse sample are needed.

References

Ahmad, N., Qamar, M., Yuan, Y., Nazir, Y., Wilairatana, P., & Mubarak, M. S. (2022). Dietary Polyphenols: Extraction, Identification, Bioavailability, and Role for Prevention and Treatment of Colorectal and Prostate Cancers. *Molecules*, *27*(9), 2831.

Akar, T., Altun, M. F., & Anber, T. (2021). Depresyon ve Toplum Ruh Sağlığı. *Türkiye Sağlık Okuryazarlığı Dergisi*, *2*(2), 99–103.

Cardona, F., Andrés-Lacueva, C., Tulipani, S., Tinahones, F. J., & Queipo-Ortuño, M. I. (2013). Benefits of polyphenols on gut microbiota and implications in human health. *The Journal of Nutritional Biochemistry*, *24*(8), 1415–1422.

Clarke, D. M., & Currie, K. C. (2009). Depression, anxiety and their relationship with chronic diseases: a review of the epidemiology, risk and treatment evidence. *Medical Journal of Australia*, *190*(S7), 54–60.

Del Rio, D., Rodriguez-Mateos, A., Spencer, J. P. E., Tognolini, M., Borges, G., & Crozier, A. (2013). Dietary (Poly)phenolics in Human Health: Structures, Bioavailability, and Evidence of Protective Effects Against Chronic Diseases. *Antioxidants & Redox Signaling*, *18*(14), 1818–1892.

Dodd, S., Maes, M., Anderson, G., Dean, O. M., Moylan, S., & Berk, M. (2013). Putative neuroprotective agents in neuropsychiatric disorders. *Progress in Neuro-Psychopharmacology & Biological Psychiatry*, *42*, 135–145.

Duffy, S. J., Keaney, J. F., Holbrook, M., Gokce, N., Swerdloff, P. L., Frei, B., & Vita, J. A. (2001). Short- and long-term black tea consumption reverses endothelial dysfunction in patients with coronary artery disease. *Circulation*, *104*(2), 151–156.

Es-safi, I., Mechchate, H., Amaghnouje, A., Kamaly, O. M. Al, Jawhari, F. Z., Imtara, H., Grafov, A., & Bousta, D. (2021). The

Potential of Parsley Polyphenols and Their Antioxidant Capacity to Help in the Treatment of Depression and Anxiety: An In Vivo Subacute Study. *Molecules*, *26*(7), 2009.

Feng, L., Gwee, X., Kua, E. H., & Ng, T. P. (2010). Cognitive function and tea consumption in community dwelling older Chinese in Singapore. *The Journal of Nutrition, Health & Aging*, *14*(6), 433–438.

Forsyth, A. K., Williams, P. G., & Deane, F. P. (2012). Nutrition status of primary care patients with depression and anxiety. *Australian Journal of Primary Health*, *18*(2), 172–176.

Friedrich, M. J. (2017). Depression Is the Leading Cause of Disability Around the World. *JAMA*, *317*(15), 1517.

Gangwisch, J. E., Hale, L., Garcia, L., Malaspina, D., Opler, M. G., Payne, M. E., Rossom, R. C., & Lane, D. (2015). High glycemic index diet as a risk factor for depression: analyses from the Women's Health Initiative. *The American Journal of Clinical Nutrition*, *102*(2), 454.

García-Lafuente, A., Guillamón, E., Villares, A., Rostagno, M. A., & Martínez, J. A. (2009). Flavonoids as anti-inflammatory agents: implications in cancer and cardiovascular disease. *Inflammation Research : Official Journal of the European Histamine Research Society ... [et Al.]*, *58*(9), 537–552.

Gharras, H. E. (2009). Polyphenols: food sources, properties and applications – a review. *International Journal of Food Science & Technology*, *44*, 2512-2518.

Godos, J., Castellano, S., Ray, S., Grosso, G., & Galvano, F. (2018). Dietary Polyphenol Intake and Depression: Results from the Mediterranean Healthy Eating, Lifestyle and Aging (MEAL) Study. *Molecules*, *23*(5), 999.

Grosso, G., Micek, A., Godos, J., Pajak, A., Sciacca, S., Galvano, F., & Giovannucci, E. L. (2017). Dietary Flavonoid and Lignan Intake and Mortality in Prospective Cohort Studies:

Systematic Review and Dose-Response Meta-Analysis. *American Journal of Epidemiology*, *185*(12), 1304–1316.

Haminiuk, C. W. I., Maciel, G. M., Plata-Oviedo, M. S. V., & Peralta, R. M. (2012). Phenolic compounds in fruits – an overview. *International Journal of Food Science & Technology*, *47*(10), 2023–2044.

Heninger, G. R., Delgado, P. L., & Charney, D. S. (1996). The revised monoamine theory of depression: A modulatory role for monoamines, based on new findings from monoamine depletion experiments in humans. *Pharmacopsychiatry*, *29*(1), 2–11.

Huang, Q., Liu, H., Suzuki, K., Ma, S., & Liu, C. (2019). Linking What We Eat to Our Mood: A Review of Diet, Dietary Antioxidants, and Depression. *Antioxidants*, *8*(9).

Joseph, J. A., Shukitt-Hale, B., & Casadesus, G. (2005). Reversing the deleterious effects of aging on neuronal communication and behavior: beneficial properties of fruit polyphenolic compounds. *The American Journal of Clinical Nutrition*, *81*(1), 313–316.

Khosravi, M., Sotoudeh, G., Amini, M., Raisi, F., Mansoori, A., & Hosseinzadeh, M. (2020). The relationship between dietary patterns and depression mediated by serum levels of Folate and vitamin B12. *BMC Psychiatry*, *20*(1).

Kontogianni, M. D., Vijayakumar, A., Rooney, C., Noad, R. L., Appleton, K. M., McCarthy, D., Donnelly, M., Young, I. S., McKinley, M. C., McKeown, P. P., & Woodside, J. V. (2020). A High Polyphenol Diet Improves Psychological Well-Being: The Polyphenol Intervention Trial (PPhIT). *Nutrients*, *12*(8), 2445.

Kulkarni, S. K., Bhutani, M. K., & Bishnoi, M. (2008). Antidepressant activity of curcumin: involvement of serotonin and dopamine system. *Psychopharmacology*, *201*(3), 435–442.

Lai, J. S., Hiles, S., Bisquera, A., Hure, A. J., McEvoy, M., & Attia, J. (2014). A systematic review and meta-analysis of dietary patterns and depression in community-dwelling adults. *The American Journal of Clinical Nutrition*, *99*(1), 181–197.

Lassale, C., Batty, G. D., Baghdadli, A., Jacka, F., Sánchez-Villegas, A., Kivimäki, M., & Akbaraly, T. (2018). Healthy dietary indices and risk of depressive outcomes: a systematic review and meta-analysis of observational studies. *Molecular Psychiatry 2018 24:7*, *24*(7), 965–986.

Leri, M., Scuto, M., Ontario, M.L., Calabrese. V., Calabrese, E.J., Bucciantini, M., & Stefani, M. (2020). Healthy Effects of Plant Polyphenols: Molecular Mechanisms. *International Journal of Molecular Sciences*, *21*,1250.

Maeda, K., Kuzuya, M., Cheng, X. W., Asai, T., Kanda, S., Tamaya-Mori, N., Sasaki, T., Shibata, T., & Iguchi, A. (2003). Green tea catechins inhibit the cultured smooth muscle cell invasion through the basement barrier. *Atherosclerosis*, *166*(1), 23–30.

Manach, C., Scalbert, A., Morand, C., Rémésy, C., & Jiménez, L. (2004). Polyphenols: food sources and bioavailability. *The American Journal of Clinical Nutrition*, *79*(5), 727–747.

Mao, Q. Q., Ip, S. P., Ko, K. M., Tsai, S. H., Xian, Y. F., & Che, C. T. (2009). Effects of peony glycosides on mice exposed to chronic unpredictable stress: further evidence for antidepressant-like activity. *Journal of Ethnopharmacology*, *124*(2), 316–320.

Maurya, P. K., & Rizvi, S. I. (2009). Protective role of tea catechins on erythrocytes subjected to oxidative stress during human aging. *Natural Product Research*, *23*(12), 1072–1079.

Milne, J. C., Lambert, P. D., Schenk, S., Carney, D. P., Smith, J. J., Gagne, D. J., Jin, L., Boss, O., Perni, R. B., Vu, C. B., Bemis, J. E., Xie, R., Disch, J. S., Ng, P. Y., Nunes, J. J., Lynch, A. V., Yang, H., Galonek, H., Israelian, K., … Westphal, C. H. (2007). Small molecule activators of SIRT1 as therapeutics for the treatment of type 2 diabetes. *Nature*, *450*(7170), 712.

Molendijk, M., Molero, P., Ortuño Sánchez-Pedreño, F., Van der Does, W., & Angel Martínez-González, M. (2018). Diet quality and depression risk: A systematic review and dose-response meta-analysis of prospective studies. *Journal of Affective Disorders*, *226*, 346–354.

Ng, T. P., Chiam, P. C., Lee, T., Chua, H. C., Lim, L., & Kua, E. H. (2006). Curry consumption and cognitive function in the elderly. *American Journal of Epidemiology*, *164*(9), 898–906.

Niu, K., Hozawa, A., Kuriyama, S., Ebihara, S., Guo, H., Nakaya, N., Ohmori-Matsuda, K., Takahashi, H., Masamune, Y., Asada, M., Sasaki, S., Arai, H., Awata, S., Nagatomi, R., & Tsuji, I. (2009). Green tea consumption is associated with depressive symptoms in the elderly. *The American Journal of Clinical Nutrition*, *90*(6), 1615–1622.

Pandey, K. B., & Rizvi, S. I. (2009). Plant polyphenols as dietary antioxidants in human health and disease. *Oxidative Medicine and Cellular Longevity*, *2*(5), 270.

Pérez-Gregorio, R., Soares, S., Mateus, N., & de Freitas, V. (2020). Bioactive Peptides and Dietary Polyphenols: Two Sides of the Same Coin. *Molecules*, *25*(15).

Piccolella, S., Crescente, G., Candela, L., & Pacifico, S. (2019). Nutraceutical polyphenols: New analytical challenges and opportunities. *Journal of Pharmaceutical and Biomedical Analysis*, *175*, 112774.

Psaltopoulou, T., Sergentanis, T. N., Panagiotakos, D. B., Sergentanis, I. N., Kosti, R., & Scarmeas, N. (2013). Mediterranean diet, stroke, cognitive impairment, and depression: A meta-analysis. *Annals of Neurology*, *74*(4), 580–591.

Rasines-Perea, Z., & Teissedre, P. L. (2017). Grape Polyphenols' Effects in Human Cardiovascular Diseases and Diabetes. *Molecules : A Journal of Synthetic Chemistry and Natural Product Chemistry*, *22*(1).

Rendeiro, C., Rhodes, J. S., & Spencer, J. P. E. (2015). The mechanisms of action of flavonoids in the brain: Direct versus indirect effects. *Neurochemistry International*, *89*, 126–139.

Rizvi, S. I., & Maurya, P. K. (2007). Alterations in antioxidant enzymes during aging in humans. *Molecular Biotechnology*, *37*(1), 58–61.

Salari-Moghaddam, A., Saneei, P., Larijani, B., & Esmaillzadeh, A. (2019). Glycemic index, glycemic load, and depression: a systematic review and meta-analysis. *European Journal of Clinical Nutrition*, *73*(3), 356–365.

Sánchez-Villegas, A., Toledo, E., De Irala, J., Ruiz-Canela, M., Pla-Vidal, J., & Martínez-González, M. A. (2012). Fast-food and commercial baked goods consumption and the risk of depression. *Public Health Nutrition*, *15*(3), 424–432.

Shukitt-Hale, B., Lau, F. C., & Josep, J. A. (2008). Berry fruit supplementation and the aging brain. *Journal of Agricultural and Food Chemistry*, *56*(3), 636–641. https://doi.org/10.1021/JF072505F

Toric, J., Markovic, A.K., Brala, C.J., Barbaric, M. Anticancer effects of olive oil polyphenols and their combinations with anticancer drugs. *Acta Pharmaceutica*, 2019, 69, 461–482.

Thomas, T., & Pfeiffer, A. F. H. (2012). Foods for the prevention of diabetes: how do they work? *Diabetes/Metabolism Research and Reviews*, *28*(1), 25–49.

Tzounis, X., Rodriguez-Mateos, A., Vulevic, J., Gibson, G. R., Kwik-Uribe, C., & Spencer, J. P. E. (2011). Prebiotic evaluation of cocoa-derived flavanols in healthy humans by using a randomized, controlled, double-blind, crossover intervention study. *The American Journal of Clinical Nutrition*, *93*(1), 62–72.

Tzounis, X., Vulevic, J., Kuhnle, G. G. C., George, T., Leonczak, J., Gibson, G. R., Kwik-Uribe, C., & Spencer, J. P. E.

(2008). Flavanol monomer-induced changes to the human faecal microflora. *British Journal of Nutrition*, *99*(4), 782–792.

Vignes, M., Maurice, T., Lanté, F., Nedjar, M., Thethi, K., Guiramand, J., & Récasens, M. (2006). Anxiolytic properties of green tea polyphenol (−)-epigallocatechin gallate (EGCG). *Brain Research*, *1110*(1), 102–115.

Vita, J. A. (2005). Polyphenols and cardiovascular disease: effects on endothelial and platelet function. *The American Journal of Clinical Nutrition*, *81*(1 Suppl).

Wang, X., Ouyang, Y. Y., Liu, J., & Zhao, G. (2014). Flavonoid intake and risk of CVD: a systematic review and meta-analysis of prospective cohort studies. *The British Journal of Nutrition*, *111*(1), 1–11.

Wedick, N. M., Pan, A., Cassidy, A., Rimm, E. B., Sampson, L., Rosner, B., Willett, W., Hu, F. B., Sun, Q., & Van Dam, R. M. (2012). Dietary flavonoid intakes and risk of type 2 diabetes in US men and women. *The American Journal of Clinical Nutrition*, *95*(4), 925.

Wild, S., Roglic, G., Green, A., Sicree, R., & King, H. (2004). Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care*, *27*(5), 1047–1053.

Woo, H. D., Lee, J., Choi, I. J., Kim, C. G., Lee, J. Y., Kwon, O., & Kim, J. (2014). Dietary Flavonoids and Gastric Cancer Risk in a Korean Population. *Nutrients*, *6*(11), 4961.

Xiao, J., & Hogger, P. (2014). Influence of diabetes on the pharmacokinetic behavior of natural polyphenols. *Current Drug Metabolism*, *15*(1), 23–29.

Yalvaç, H. D. (2012). Depresyonun Epidemiyolojisi. *Turkiye Klinikleri*, *5*(2), 7–13.

Yamakoshi, J., Tokutake, S., Kikuchi, M., Kubota, Y., Konishi, H., & Mitsuoka, T. (2001). Effect of Proanthocyanidin-

Rich Extract from Grape Seeds on Human Fecal Flora and Fecal Odor. *Microbial Ecology in Health and Disease*, *13*(1), 25–31.

Yang, C. S., Landau, J. M., Huang, M. T., & Newmark, H. L. (2001). Inhibition of carcinogenesis by dietary polyphenolic compounds. *Annual Review of Nutrition*, *21*, 381–406.

Zahedi, M., Ghiasvand, R., Feizi, A., Asgari, G., & Darvish, L. (2013). Does Quercetin Improve Cardiovascular Risk factors and Inflammatory Biomarkers in Women with Type 2 Diabetes: A Double-blind Randomized Controlled Clinical Trial. *International Journal of Preventive Medicine*, *4*(7), 777.

Zamora-Ros, R., Not, C., Guinó, E., Luján-Barroso, L., García, R. M., Biondo, S., Salazar, R., & Moreno, V. (2013). Association between habitual dietary flavonoid and lignan intake and colorectal cancer in a Spanish case-control study (the Bellvitge Colorectal Cancer Study). *Cancer Causes & Control: CCC*, *24*(3), 549–557.

Zhu, W.-L., Shi, H.-S., Wei, Y.-M., Wang, S.-J., Sun, C.-Y., Ding, Z.-B., & Lu, L. (2012). Green tea polyphenols produce antidepressant-like effects in adult mice. *Pharmacological Research*, *65*(1), 74–80.


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