



Role of diet in primary and secondary prevention of periodontitis and non-specific inflammatory bowel diseases. Part II

Małgorzata Goździewska^{1,A-B,D-E}✉, Aleksandra Łyszczarz^{2,A-B,F}, Monika Kaczoruk^{1,A-F},
Emilia Kolarzyk^{3,A-F}

¹ Institute of Rural Health, Lublin, Poland

² Student of the Faculty of Medicine and Dentistry, Jagiellonian University Medical College, Kraków, Poland

³ Higher School of Health Promotion, Kraków, Poland

A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

Goździewska M, Łyszczarz A, Kaczoruk M, Kolarzyk E. Role of diet in primary and secondary prevention of periodontitis and non-specific inflammatory bowel diseases. Part II. *Ann Agric Environ Med.* 2024; 31(2): 170–177. doi: 10.26444/aaem/190438

Abstract

Introduction and Objective. Both periodontitis and non-specific bowel diseases (IBD) are complex chronic diseases, and the elements connecting them are the dysregulated microbiota and abnormal immune response of the host. In turn, in the etiology of these diseases, the common environmental risk factor is improper mode of nutrition. The aim of the study is to review nutritional interventions and effective nutritional protocols applied in periodontitis and IBD. The result of the review will be identification of dietary recommendations exerting a beneficial effect on the reduction of the risk of development and alleviation of the severity of both diseases. At the same time, non-recommended dietary choices will be indicated.

Review Methods. A review of literature was carried out using the databases PubMed, Google Scholar, and Web of Science. Publications were analyzed by a non-systematic literature review aimed at making a brief synthesis of the collected information.

Brief description of the state of knowledge. Diets recommended to patients with both periodontitis and IBD included the Mediterranean diet, DASH diet and vegetarian diet; excluding veganism, raw foodism and fruitarianism. For patients with IBD, special dietary recommendations were elaborated on the recommendations of the International Organization for Research into Inflammatory Bowel Diseases (IOIBD), and specific diets, i.e. specific carbohydrate diet (SCD), and Groningen anti-inflammatory diet (GrAID). In the process of treatment of oral and intestinal dysbiosis, probiotic therapy is beneficial in both diseases, specified as the Western diet. Non-conventional diets are not recommended.

Summary. Diet therapy for inflammatory periodontal diseases and IBD requires extensive individualization; nevertheless, a universal principle is avoidance of highly processed food, and implementation of easily digestible meals based on natural, ecological products. Proper nutrition plays a crucial role in primary prevention of both diseases analyzed, whereas in secondary prevention, diet therapy is a valuable supplementation of pharmacotherapy.

Key words

inflammatory bowel diseases, diet nutritional recommendations, gut microflora, oral microflora, periodontal diseases

INTRODUCTION

The authors of the majority of reports quoted in the first part of this study agree that environmental factors play an important role in the etiology of periodontal and bowel diseases [1]. Among these factors, an anti-health life style is mentioned, especially improper nutrition, insufficient physical activity, acute and chronic stress, or cigarette smoking. It should be emphasized that issues related with nutrition are usually the most important problem requiring instant action. There is an unquestionable relationship between diet and nutritional status, and the general state of physical and psychological health in people affected by the disease, as well as those who are healthy. Therefore, experts from the Institute of Food and Nutrition developed recommendations for proper nutrition for the Polish population, and defined 10 basic principles related with the Pyramid of Healthy Eating and Physical Activity. The pyramid was developed based on

the guidelines by the WHO, and adjusted to the needs of children and adolescents [2]. It constitutes a set of universal principles of healthy eating for healthy persons. A separate type of pyramid was developed for adults [3] and seniors [4]. In, and in the case of people diagnosed with nutrition-related diseases, its modification is recommended.

Currently, an alternative for the Healthy Eating Pyramid is the Healthy Eating Plate. This model is illustrated in the form of a plate full of various products that should be included in a healthy diet. MyPlate has sections for vegetables, fruits, grains, and protein foods, as well as a ‘cup’ on the side for dairy. Colour-coded sections — green for vegetables, red for fruits, orange for grains, purple for protein, and blue for dairy — show at a glance how much of these foods to eat. This method is more practical for daily use and more specific in term of quantities.

The use of personalized nutritional recommendations is aimed at alleviation of undesirable symptoms of periodontal and bowel disease, which may exert a positive effect on the nutritional status [5]. In addition, the diversity of human intestinal microflora is determined by eating habits; hence, dietary choices may play an important role in the modulation

✉ Address for correspondence: Małgorzata Goździewska, Institute of Rural Health, Lublin, Poland
E-mail: malgorzata.gozdziewska@gmail.com

Received: 21.03.2024; accepted: 11.06.2024; first published: 23.06.2024

of the bacterial flora, especially in persons with inflammatory diseases [6].

The second part of the review will therefore focus on analysis of the dietary recommendations which may bring benefits in primary and secondary prevention of periodontitis and non-specific inflammatory bowel diseases. The aim of the study is to analyse nutritional interventions and determine the most effective nutritional protocols which may positively affect both the reduction of the risk of development, and alleviation of the severity of the course of periodontitis and non-specific bowel diseases.

REVIEW METHODS

The presented literature review focuses on summing-up current scientific evidence concerning the relationship between oral and intestinal microflora, with consideration of dietary factors. The results of the study are an indication of the style of nutrition best protecting the body against the development of inflammatory diseases, which has an effect on alleviation of the negative consequences of these diseases. In this narrative review, possible implications of nutrition are examined as a protective factor related with IBD and periodontal diseases, considering the possibility of the development of new prophylactic strategies.

The review was carried out using databases PubMed, Google Scholar, and Web of Science. Publications were analyzed by a non-systematic survey aimed at a brief synthesis of the collected information.

DESCRIPTION OF THE STATE OF KNOWLEDGE:

Periodontitis and mode of nutrition. In persons with periodontitis a correct and well-balanced diet adjusted to the needs of pathologically changed body plays a key role, in this case to the needs of the oral cavity. The relationship between the mode of nutrition and the occurrence of periodontal diseases was assessed in a cohort study – the Hamburg City Health Study (HCHS), which included 6,209 people. In the examined group, periodontal diagnostics were performed, including probing the depth of cavities, receding gums, plaque index, and bleeding during probing. In addition, the mode of nutrition was assessed using a food frequency questionnaire (FFQ2).

Using the method of ordinal regression analysis, it was confirmed that proper consumption of macro- and micro-food components typical of the DASH diet and Mediterranean diet, plays an important role in the both primary and secondary prevention of periodontal diseases [7]. The relationship between diet and the periodontal condition was also assessed in the American study NHANES [8]. In the NHANES 2011–2014 study, which included 7,081 people, and NHANES 2001–2004, which included 5,098 participants, the relationship was investigated between a diet rich in pro-inflammatory ingredients and poor periodontal status [9]. For each study participant, a 24-hour nutritional interview was analyzed, and the energy-adjusted dietary inflammation index (E-DII) calculated. Periodontitis was defined by the Disease Control and Prevention: CDC / American Academy of Periodontology AAP (CDC/AAP), based on the clinical parameters of the periodontium. It was confirmed that in persons with the highest E-DII, a key role tertile for the risk

of development of periodontitis was by 53 % higher than in people who applied a diet with the lowest E-DII tertile. Therefore, the researchers concluded that the consumption of a pro-inflammatory diet assessed by the E-DII index, is significantly related with the occurrence of periodontal diseases in the general population of adults in the USA [9].

In other studies, products included in the diet were specified which protect against the development of inflammatory oral diseases, and those with an unfavourable effect. It was confirmed that the diet containing large amount of saccharose and fats rich with saturated fatty acids, with a simultaneous low content of fibre and fats containing polyunsaturated fatty acids, increases the risk of periodontal diseases. This type of diet is characteristic of highly developed countries and is called the Western diet [10]. The results of the Health 2000 and 2011 study (BRIF8901) showed that the Finish diet, based on the Nordic nutritional culture and assessed using the Baltic Sea Diet Score (BSDS), also induced the development of periodontal diseases in the population of adults at middle age [11]. At the same time, it was confirmed that products and their amount typical of the Mediterranean diet and DASH, as well as a well-balanced vegetarian diet (i.e. low content of saccharose and a high content of fibre, polyphenols and polyunsaturated fatty acids), decreased the risk of periodontal diseases [9]. Similar relationships were described in a study by Santonocito et al. [12]. The researchers also confirmed that a non-balanced intake of vitamins and minerals may intensify periodontitis [12]. In the American study National Health and Nutrition Examination Survey (NHANES, 2009–2014), which included 5,530 participants, a dose-response relationship was assessed between the consumption of vitamins and microelements, and periodontitis. It was found that the risk of periodontal diseases decreases when proper amounts of vitamins A, B1, B2 and vitamin E are consumed. In turn, this risk increases in the case of an excessive intake (above the RDA) of vitamin B1 (1.8 mg/kg daily – males; 1.3 mg/kg daily -females), vitamin C (90 mg/daily – males), and copper (1.1 mg/daily – both males and females). Special attention should be devoted to vitamin C, because in this study an unfavourable effect of an excessive intake of vitamin C was demonstrated, while other studies showed that an insufficient intake of this vitamin may lead to the development of necrotizing-ulcerative gingivitis. Ascorbic acid also participates in the synthesis of collagen and intercellular substance, which are necessary for the proper development of cartilage, bones and teeth. Generalizing, it should be noted that both an insufficient and excessive intake of vitamins and microelements may contribute to the development of pathological changes in the oral cavity [13].

Currently, efforts are being undertaken to show that the treatment of periodontal diseases is related with modulation of the immune response [14]. It turns out that in achieving this goal, a diet rich in omega-3 polyunsaturated fatty acids may be helpful [15]. They may inhibit synthesis of lipid mediators of inflammation, modify cellular functions of the polymorphonuclear leukocytes, and modulate the proliferation of lymphocytes and production of pro-inflammatory cytokines. Patients treated for three months with EPA and DHA, and scaling root planning, showed improved clinical attachment levels [16]. An earlier study conducted on rats infected with *Porphyromonas gingivalis* (*P. gingivalis*) demonstrated that dietary supplementation with omega-3 acids decreased the inflammatory state of the periodontium and promoted bone regeneration [17].

Generalizing the results of the above-quoted studies, and based on clinical observations, it can be presumed that in the case of periodontitis, the diets recommended, due to their composition, include the Mediterranean diet, DASH diet, and vegetarian diets; but excluding the restrictive forms (veganism, raw foodism, fruitarianism). In turn, from the aspect of the technique of preparation of meals, this diet should be easily digestible, in which the recommended method of preparation of meals is, among others, cooking in water or steaming, modified stewing – fat-free frying in a non-stick teflon pan, and stewing in a small amount of water or baking in parchment paper. The consistency of the food consumed is also important. Foods with a pasty or sticky consistency worsen the oral hygiene, which simultaneously favours the development of inflammatory states. However, the hard consistency of also food requiring longer chewing leads to an increase in the rate of salivation, which exerts a beneficial effect on the process of cleaning the oral cavity. In addition, Highly processed products should be excluded from the diet and natural products should be introduced. The balanced intake of unprocessed complex carbohydrates, plant proteins, and omega-3 fatty acids, has a preventive effect. In turn, refined carbohydrates, saturated fatty acids and trans fatty acids, and an unbalanced intake of vitamins and minerals inconsistent with recommendations, may intensify periodontitis [12]. The diet should consist of fruit and vegetable, including also legumes and whole grain products, which are a source of vitamins, minerals and fibre. It is also important to take into account an individual approach, which allows or excludes the consumption of milk and dairy products, including fermented milk products. It is generally assumed that dairy products play an important role in the reduction of the risk of development of periodontal diseases; this is because they contain high amounts of vitamin D, calcium and phosphorus. It should be emphasized that in milk and derived products the ratio of calcium and phosphorus optimal for the structure and strength of bone tissue is 1.7:1. Calcium has a beneficial effect on periodontal tissues by participating in the regulation of bone density in the skeleton and crestal bone. Vitamin D participates to a high degree in maintaining proper calcium and phosphate metabolism, and additionally has an effect on maintaining the proper structure and function of the skeleton, and through its immunomodulatory effect may result in a decreased susceptibility of the patient to periodontitis. Milk and its products are also rich in casein which reduces the accumulation of tartar [18].

Food rich in naturally occurring antioxidants (i.e. vitamin C, vitamin E, beta-carotene, lutein, anthocyanins, polyphenols and bio-elements: zinc, copper, selenium, manganese and cobalt), plays a very important role in the treatment of periodontal diseases [10,19]. However, no studies were found that would allow the consumption of sweets and sweetened beverages in the prevention of periodontal diseases, and it was confirmed that an increase in the intake of refined sugar leads to increased bleeding from the gums. A study by Almoznino et al. demonstrated that persons with periodontitis applying an inappropriate diet, compared to those from the control group, had higher BMI values and a worse quality of life related with oral health (OHRQoL) [20]. It was also confirmed that OHRQoL deteriorates together with an increase in the intensity of periodontitis [21].

Non-specific inflammatory bowel diseases and mode of nutrition. The International Organization for Research into Inflammatory Bowel Diseases (IOIBD) deals with the holistic approach to the scope of problems of IBD in the areas of diet therapy and pharmacotherapy, as well as health promotion and health education. It is the only organization of this type with an international reach, which in 2020, formulated nutritional recommendations for patients with IBD, aimed at the alleviation of symptoms and, consequently, improvement of the quality of life of patients [23]. The document was prepared by 12 experts from various countries. The basic principle determining the adoption of a given recommendation was obtaining the approval of >75% of members of the working group who participated in the formulation of the Dietary Guidance. Consensus was reached for all food groups, with the exception of pasteurized dairy products. The recommendations took into account the impact of a given dietary component on the intensity of symptoms and/or inflammatory state in IBD. However, the impact of co-morbidities on the choice of diet was not taken into consideration.

According to the IOIBD, a moderate consumption of vegetables and fruits is recommended to the majority of patients with IBD; however, patients with CD who suffer from intestinal strictures should limit their consumption of vegetables and fruits with a high content of insoluble dietary fibre fraction. Recommendations concerning the consumption of carbohydrates, both in terms of simple sugars and polysaccharides, are analogous to those for the general population of healthy people. This does not apply only to patients with CD, as well as UC, in whom the symptoms of the disease persist despite the resolution of inflammation, and there are no strictures in the digestive tract. These patients are recommended to apply a diet with a low content of low-fermentable oligosaccharides, disaccharides, monosaccharides and polyols (lowFODMAP) [24]. However, there is no consensus among experts regarding the necessity for limiting the consumption of wheat protein and gluten by patients with IBD. Although some studies showed an alleviation of the course of the disease in patients who excluded the consumption of gluten, they simultaneously limited the consumption of FODMAP; thus, it could have been a synergistic effect [25, 26].

Moderate consumption of unprocessed red meat, lean poultry meat (e.g. chicken breast) and eggs is allowed for patients with CD. However, patients with UC should aim to exclude red meat and its products from their diet. In the current study, a relationship was found between high consumption of red meat and the frequency of recurrences of the disease in patients with UC, whereas no such relationship was confirmed in patients with CD [27].

The IOIBD is unequivocally against the consumption of milk and unpasteurized products. Studies have shown a more frequent occurrence of lactose intolerance in patients with CD and UC, compared to persons without these complaints [28]. The IOIBD experts did not succeed in establishing a common position regarding unpasteurized dairy products in the diet of patients with IBD. This results from the fact of the complex composition of dairy products containing both potentially hazardous substances, and those which are not only harmless, but constitute an important component of a balanced diet. It is certain, however, that all patients with IBD should avoid the consumption of unpasteurized milk.

The IOIBD experts developed detailed recommendations concerning the consumption of particular fatty acids. All patients with IBD should exclude from their diet fats rich in saturated fatty acids and trans. Additionally, patients with UC were recommended to limit the consumption of myristic acid present in palm fat, coconut fat, beef fat and dairy products. It is important to increase the consumption of n-3 polyunsaturated fatty acids, i.e. eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA); however, they should come from marine fish, but not from dietary supplements, because there is no scientific evidence confirming a beneficial role of omega-3 fatty acids supplementation in patients with IBD.

According to the IOIBD recommendations, all patients with IBD should resign from processed food, so-called convenience food. Nevertheless, there is insufficient scientific evidence indicating the need for limiting the consumption of small amounts of alcohol in IBD.

The development of universal nutritional recommendations for all patients with IBD is practically impossible. Specialists from the Clinic of Gastroenterology at the Jagiellonian University Medical College in Kraków, Poland [29], emphasize that diet requires far-reaching individualization. While developing nutritional plans for patients with inflammatory bowel diseases it is necessary to consider the current course of the disease, past surgical procedures, and type of pharmacology applied. Proper nutrition during specific periods of the disease may facilitate achieving or prolonging remission, and primarily improve the quality of life of patients. Importantly, during the period of exacerbation of the disease in the majority of patients the experts recommend a diet low in fibre. In turn, in patients with a chronic inflammatory condition and long-term users of pharmacotherapy, the adjustment of proper nutritional procedures may contribute to the reduction of risk of the occurrence of vitamin and microelement deficiencies, primarily: iron, calcium, vitamin A, vitamin D, vitamin B12, folic acid, zinc, and magnesium [29] (Fig. 1).

Safe and not recommended models of nutrition for patients with inflammatory bowel diseases and periodontal diseases.

In the light of this literature review, it seems that a safe model of nutrition in the situation of inflammatory bowel diseases, similar to periodontitis [7], is the Mediterranean diet [30,31]. This diet is based on products which are commonly available and, at the same time, of high nutritional value. The traditional Mediterranean diet is characterized by high consumption of raw vegetables and fruits, legume seeds, vegetable oils, nuts and seeds, as well as dairy products and fish, while the supply of red meat, especially all processed meat, is low. The diet ensures the supply of all macro- and micronutrients necessary for a pathologically changed organism, and through the high content of compounds with an antioxidant effect, such as vitamins A, C, β -carotene, anthocyanins and polyphenols, and bioelements: zinc, copper, selenium, manganese and cobalt, may show an anti-inflammatory effect. A study by F. Chicco et. al. showed that in 142 patients with IBD after six months of application of Mediterranean diet, a reduction was observed in the activity of the disease, and an improvement in the values of inflammatory markers (C-reactive protein and faecal calprotectin) [32]. A study by Papada E. also demonstrated a considerable improvement in the quality of life of patients after introducing the nutritional principles of the Mediterranean diet [33].

Among practically applied models of nutrition for patients with IBD, there is also the specific carbohydrate diet (SCD), which is an elimination diet involving the reduction of polysaccharides and disaccharides. It is necessary to exclude from the diet wheat grains, oats, barley, corn, quinoa and rice, dairy products (except hard cheeses and lactic fermentation products), and replacing sugar with honey. This diet is based on the assumption that complete exclusion, or even limitation of the supply of disaccharides and complex carbohydrates, leads to the inhibition of intestinal dysbiosis, and thus alleviates the body's immune response [34].

Some researchers compared the SCD diet and Mediterranean diet in the context of their effect on the course

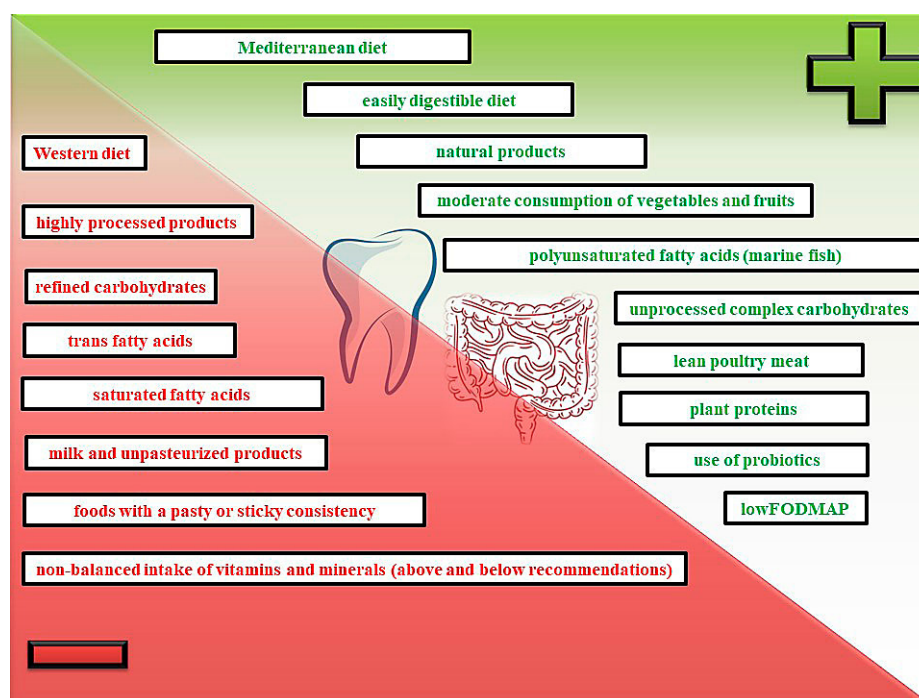


Figure 1. Health-promoting and anti-health ingredients that act in periodontitis and IBD

of IBD. Lewis et al. indicated that in nearly a half from among 194 patients in the study, already after six weeks of application of the SCD or Mediterranean diet there was a reduction in the Crohn's disease activity index (CDAI < 150), and the effects lasted for the next six weeks of dieting. In addition, no bacterial dysbiosis was found in these patients, while a reduction was observed in both CRP and faecal calprotectin. However, the researchers considered that despite similar outcomes resulting from the application of both diets, in the majority of patients with mild to moderate symptoms of CD, the Mediterranean diet may be preferred over the SCD, considering the greater ease of compliance with the recommended pharmacotherapy and diet therapy, and proven systemic health benefits [35]. In turn, a study by Limketkai et al. demonstrated that benefits from the application of both diets in patients with IBD were comparable [36].

It is also worth mentioning the anti-inflammatory Groningen diet (GrAID) which has been specially designed for patients with IBD [37]. The composition of the GrAID diet includes lean meat, eggs, fish, dairy products – especially fermented (kefir, yogurt, buttermilk), fruits, vegetables, legumes, nuts, seeds, whole grain cereal products, coffee, tea and honey. Canned and processed foods should be avoided, as well as red meat, simple carbohydrates, saturated fatty acids (found mainly in animal products), fast food, salty snacks, sweetened beverages and alcohol.

Jaramillo et al. confirmed that changes in the diet, including increasing the intake of anti-inflammatory foods and reducing the intake of foods rich in inflammatory compounds, are associated with beneficial outcomes, both metabolic and microbiological, in patients with ulcerative colitis at the stage of remission [38].

A pattern of anti-inflammatory diet has also been developed which is a modification of SCD, applicable in the case of patients with periodontitis, as well as those with inflammatory bowel diseases. The modification consists in the introduction of a high amount of prebiotics and probiotics. The undisputed fact is that an integral part of healthy microflora of the mouth and intestines is the community of microorganisms. The oral cavity and intestines are not only anatomically connected, but also by microbiomes living in these organs (with a greater share of oral microorganisms in the intestines) [39,40]. The American Gastroenterological Association (AGA) recommends the use of probiotics in the treatment of colitis. The use of combination of eight strains is recommended, i.e. *L. paracasei* DSM 24733, *L. plantarum* DSM 24730, *L. acidophilus* DSM 24735, *L. delbrueckii* subsp. *bulgaricus* DSM 24734, *B. longum* DSM 24736, *B. infantis* DSM 24737, *B. breve* DSM 24732 and *S. thermophilus* DSM 247 [41, 42]. A study by Lourenco et al. showed that in patients with periodontitis the intestinal microflora is usually less diverse, and characterized by an increase in the *Firmicutes/Bacteroidetes* ratio, and enrichment with *Euryarchaeota*, *Verrucomicrobia* and *Proteobacteria* [43].

Nowadays, the search for new therapeutic approaches in order to restore microbial dysbiotic conditions at the individual level is a challenge. The WHO ion considered resistance to antimicrobial agents as one of the 10 most important global threats to public health, and regarded by the European Commission as one of the three most important health risks in the EU [44, 45]. The fact is that a promising strategy which can restore the body's microbiological balance is probiotic therapy. The use of probiotic strains is

recommended primarily in order to strengthen immunity, and as a form of supportive treatment, among others, in diseases on an inflammatory background [46]. Although this practice does not result in complete recovery, it improves the comfort of life. It was confirmed that probiotic therapy plays a beneficial role in the process of treatment of dysbiosis of the oral cavity and intestines, by rebuilding the epithelial membrane, resulting in a reduction in systemic inflammation. Probiotic strains can compete with pathogenic bacteria for adhesion surfaces and nutrients. As a result, it was found that probiotic bacteria adhere better to the surface, which causes the displacement of pathogenic bacteria, and consequently the formation of a healthy biofilm [47, 48].

Probiotics stimulate dendritic cells, contributing to the expression of Th1 and Th2 cells, which are responsible for the modification of the immune response of the host [49]. Based on the assumptions of the gum-gut axis concept, combining periodontal disease and systemic diseases, a study carried out by Kobayashi et al. demonstrated in a mouse model that oral probiotic therapy reduces the destruction of periodontal tissue, and modulates the immune response in the intestines of periodontitis [50]. In addition, Singh et al. suggested a potential role of probiotics, microflora dysbiosis, in the prevention and treatment of cancers, in particular liver and oral cancers [51]. In turn, a study by Choi et al., concerning analysis of the effect of fermented milk *Lactobacillus curvatus* SMFM2016-NK on periodontal disease and intestinal health in a rat, showed that the use of fortified foods may reduce gene expression related with pro-inflammatory cytokines [52]. Therefore, the use of probiotic strains, or foods containing probiotics, is worth considering in the alleviation of the symptoms of periodontal diseases and intestinal dysbiosis. However, the AGA indicated that there are no universal guidelines concerning the use of probiotics by all patients, and individual recommendations should be developed, based on the current results of clinical examinations [41, 42].

Increasingly more often, patients with diseases on an inflammatory background begin to apply various types of non-conventional diets, among which the ketogenic diet (KD) has become especially popular. KD is a combination of low-carbohydrate and high-fat diet, developed in 1920 to treat treatment-resistant epilepsy with good results. It gained popularity in the 1970s when used for weight loss. In recent years, increasing evidence has emerged suggesting that the ketogenic diet, apart from the benefits related with weight loss and obesity-related cardiovascular diseases, shows anti-inflammatory effect, protects the function of the intestinal barrier, reduces the innate production of lymphoid cells (ILC3), and decreases expression of the related inflammatory cytokines compared with LCD [53]. However, the latest studies show that KD increases intestinal damage by modifying intestinal microbes, metabolomic changes in intestinal flora, damages the intestinal barrier, and exacerbates inflammation in the blood and colon [54]. The real role KD plays in patients with IBD remains unknown, and long-term effects of KD require further studies [55, 56, 57]. Analogous objections are raised with relations to other non-conventional diets.

Similar to periodontitis, in patients with IBD the Western mode of nutrition typical of highly developed countries, is not recommended. The life style called Westernization is characterized by a life of constant rush and stress, frequent use of stimulants, insufficient physical activity,

and improper mode of nutrition [58]. The Western diet is rich in red and processed meats, sweet and salty snacks, and fatty dairy products. Such a diet contains insufficient amounts of vegetables and fruits, legumes and whole grain products, low-fat and semi-skimmed dairy products, lean unprocessed meat. The consequence is an excessive supply of simple sugars, saturated fatty acids and trans fatty acids, with an insufficient supply of vitamins and mineral compounds. All these nutrition mistakes can lead to the development of so-called civilization diseases, and data from literature provide evidence that these mistakes also play a great role in the etiology of non-inflammatory bowel diseases [59,60].

In the majority of the developed Western countries food rich in sugar has been considered as one of the risk factors of Crohn's disease. Artificial food additives common in the Western diet may favour intestinal inflammation by disrupting the proper function of the intestinal barrier. An excessive supply of not only saturated fatty acids, but also omega-6 polyunsaturated fatty acids in the diet, especially with a great disproportion in relation to fatty acids of omega-3 family, are factors inducing inflammatory condition 3 [61, 62, 63]. An insufficient supply of insoluble fibre and an excessive content of fat in the diet, leads to bacterial dysbiosis [64].

A study by Niewiadomski et al. demonstrated that the consumption of fast food more frequently than once a week was strongly related with the risk of UC higher by 43%, and risk of CD higher by 27% [65]. The Western diet may also be the cause of metabolic endotoxaemia, by increasing the number of endotoxin-producing bacteria, and increasing intestinal permeability [66].

SUMMARY

The concept of the gum-gut axis assumes that the oral cavity and intestinal tract are interconnected and can influence each other, especially from an immunological and microbiological point of view [67, 68]. This corresponds to the research results presented in the first part of this review, evidencing a close relationship between inflammatory oral diseases, especially periodontitis, and non-specific inflammatory bowel diseases [1].

The development of effective, unified recommendations concerning the optimum method of prevention and treatment, and a universal diet for patients with IBD and inflammatory periodontal conditions, presents many difficulties. This results from the fact of the high individual variability in the body's metabolic response to particular dietary components, increasingly more frequent occurrence of food intolerances, and more often diagnosed polymorbidity. Data from literature and clinical observations indicate that the common element of all recommendations should be avoidance of highly processed foods rich in additives, the task of which is to improve taste, consistency and attractiveness. In turn, it is advisable to introduce natural menus, ecological products, and preparation of easily digestible meals, with consideration of pro-health cooking methods. Translating these recommendations into the type of diet, the most typical example of the recommended diet is the Mediterranean diet, whereas the Western diet is an example of a diet not to be recommended.

At present, manipulating the microbiota has become a promising method for prevention and achieving remission of diseases on the inflammatory background. However,

it is necessary to carry out studies aimed at specification of specific probiotic molecules and their key parameters in terms of optimal dose, strain potency, and desired host response, or a specific place in the body [69]. To date, there is no solid evidence that any dietary intervention in itself can replace standard therapies in patients with oral and intestinal inflammatory diseases. Nevertheless, a proper mode of nutrition may play a crucial role in the primary prevention of these diseases, and secondary prevention diet therapy is considered as a valuable supplementation of pharmacotherapy. In order to achieve positive results, the implementation of the principles of a healthy life style by the patients themselves is also necessary, including especially the level of physical activity well-adjusted to individual abilities, and acquiring the skills to effectively cope with psychological stress.

REFERENCES

- Goździewska M, Łyszczarz A, Kaczoruk M, Kolarzyk E. Relationship between periodontal diseases and non-specific inflammatory bowel diseases – an overview. Part I. *Ann Agric Environ Med.* 2024;31(1):1–7. <https://doi.org/10.26444/aaem/185764>
- Jarosz M. Nowa piramida zdrowego żywienia i stylu życia dzieci i młodzieży. *Żywnienie Człowieka i Metabolizm.* 2019;46(01):13–14.
- Jarosz M. Piramida Zdrowego Żywienia i Aktywności Fizycznej dla osób dorosłych. Narodowe Centrum Edukacji Żywnieniowej <https://ncez.pzh.gov.pl/abc-zywienia/zasady-zdrowego-zywienia/piramida-zdrowego-zywienia-i-aktywnosci-fizycznej-dla-osob-doroslych-2/> (access: 2024.03.14).
- Jarosz M. Piramida Zdrowego Żywienia i Aktywności Fizycznej dla osób w wieku starszym. Narodowe Centrum Edukacji Żywnieniowej <https://ncez.pzh.gov.pl/seniorzy/piramida-zdrowego-zywienia-i-aktywnosci-fizycznej-dla-osob-w-wieku-starszym-4> (access: 2024.03.14).
- Janion K, Walkiewicz K, Copija A, Nowakowska-Zajdel E. Praktyczne zalecenia żywieniowe w trakcie chemioterapii u chorych na nowotwory przewodu pokarmowego. *Piel Pol.* 2018;3(69):298–304. <http://dx.doi.org/10.20883/pielpol.2018.37>
- Pigneur B, Rueemle FM. Nutritional interventions for the treatment of IBD: current evidence and controversies. *Therap Adv Gastroenterol.* 2019;25(12):1756284819890534. doi:10.1177/1756284819890534
- Altun E, Walther C, Borof K, Petersen E, Lieske B, Kasapoudis D, et al. Association between Dietary Pattern and Periodontitis—A Cross-Sectional Study. *Nutrients.* 2021;13(11):4167. <https://doi.org/10.3390/nu13114167>
- Wright D, M, McKenna G, Nugent A, Winning L, et al. Association between diet and periodontitis: a cross-sectional study of 10,000 NHANES participants. *AJCN.* 2020;112(6):1485–1491.
- Li A, Chen Y, Schuller AA, van Der Sluis, et al. Dietary inflammatory potential is associated with poor periodontal health: A population-based study. *J Clin Periodontol.* 2021;48(7):907–918. doi:10.1111/jcpe.13472
- Martinon P, Fraticelli L, Giboreau A, Dussart C, Bourgeois D, Carrouel F. Nutrition as a key modifiable factor for periodontitis and main chronic diseases. *J Clin Med.* 2021;10(2):197. <https://doi.org/10.3390/jcm10020197>
- Jauhainen LM, Ylöstalo PV, Knuutila M, Männistö S, et al. Poor diet predicts periodontal disease development in 11-year follow-up study. *Community Dent Oral Epidemiol.* 2019;48(2):143–151. doi:10.1111/cdoe.12513
- Santonocito S, Polizzi A, Palazzo G, Indelicato F, et al. Dietary factors affecting the prevalence and impact of periodontal disease. *Clin Cosmet Investig Dent.* 2021;13:283–292. doi:10.2147/CCIDE.S288137
- Li W, Shang Q, Yang D, Peng J, et al. Abnormal Micronutrient Intake Is Associated with the Risk of Periodontitis: A Dose–response Association Study Based on NHANES 2009–2014. *Nutrients.* 2022;14(12):2466. doi:10.3390/nu14122466
- Chatterjee D, Chatterjee A, Kalra D, Kapoor A, Vijay S, Jain S. Role of adjunct use of omega 3 fatty acids in periodontal therapy of periodontitis. A systematic review and meta-analysis. *J Oral Biol Craniofac Res.* 2022;12(1):55–62. <https://doi.org/10.1016/j.jobcr.2021.10.005>

15. Azuma MM, Cardoso CBM, da Silva CC, de Oliveira PHC, Jacinto RC, Andrada AC, et al. The use of omega-3 fatty acids in the treatment of oral diseases. *Oral Dis.* 2022;28(2):264–74. <https://doi.org/10.1111/odi.13667>
16. Stando M, Piatek P, Namiecinska M, Lewkowicz P, Lewkowicz N. Omega-3 polyunsaturated fatty acids EPA and DHA as an adjunct to non-surgical treatment of periodontitis: a randomized clinical trial. *Nutrients.* 2020;12(9):2614. <https://doi.org/10.3390/nu12092614>
17. Woelber JP, Gartner M, Breuning L, Anderson A, Konig D, Hellwig E, et al. The influence of an anti-inflammatory diet on gingivitis. A randomized controlled trial. *J Clin Periodontol.* 2019;46(4):481–90. <https://doi.org/10.1111/jcpe.13094>
18. Kantorowicz M, Olszewska-Czyż I, Lipska W, Kolarzyk E, Chomyszyn-Gajewska M. Impact of dietary habits on the incidence of oral diseases. *Dent Med Probl.* 2022;59(4):547–554. doi:10.17219/dmp/134749
19. Casarin M, da Silveira TM, Bezerra B, Pirihi F, et al. Association between different dietary patterns and eating disorders and periodontal diseases. *Front Oral Health.* 2023;22(4):1152031. doi:10.3389/froh.2023.1152031
20. Almozni G, Gal N, Levin L, Mijiritsky E, et al. Diet Practices, Body Mass Index, and Oral Health-Related Quality of Life in Adults with Periodontitis – A Case – Control Study. *Int J Environ Res Public Health.* 2020;17(7):2340. <https://doi.org/10.3390/ijerph17072340>
21. Wellapuli N, Ekanayake L. Association between chronic periodontitis and oral health-related quality of life in Sri Lankan adults. *Int Dent J.* 2016;66:337–343.
22. Levine A, Rhodes JM, Lindsay JO, Abreu MT, et al. Dietary Guidance from the International Organization for the Study of Inflammatory Bowel Diseases. *Clin Gastroenterol Hepatol.* 2020;18:1381–1392. doi:10.1016/j.cgh.2020.01.046
23. Niezgodka Klószak A, Eder P. Dieta w nieswoistych chorobach zapalnych jelit. Omówienie wskazówek International Organization for the Study of Inflammatory Bowel Disease 2020. *Med Prakt.* 2021;11:58–65.
24. Cox SR, Lindsay JO, Fromentin S, Stagg AJ, et al. Effects of Low FODMAP diet on symptoms, fecal microbiome, and markers of inflammation in patients with quiescent inflammatory bowel disease in a randomized trial. *Gastroenterology.* 2020;158(1):176–188.e7. doi:10.1053/j.gastro.2019.09.024
25. Pedersen N, Ankersen DV, Felding M, Wachmann H, et al. Low-FODMAP diet reduces irritable bowel symptoms in patients with inflammatory bowel disease. *World J Gastroenterol.* 2017;14(23):3356–3366. doi:10.3748/wjg.v23.i18.3356
26. Schreiner P, Yilmaz B, Rossel JB, Franc Y, et al. Swiss IBD Cohort Study Group. Vegetarian or gluten-free diets in patients with inflammatory bowel disease are associated with lower psychological well-being and a different gut microbiota, but no beneficial effects on the course of the disease. *United Eur Gastroenterol J.* 2019;7(6):767–781. doi:10.1177/2050640619841249
27. Barnes EL, Nestor M, Onyewadume L, de Silva PS, Korzenik JR. DREAM Investigators. High dietary intake of specific fatty acids increases risk of flares in patients with ulcerative colitis in remission during treatment with aminosalicylates. *Clin Gastroenterol Hepatol.* 2017;15(9):1390–1396. doi:10.1016/j.cgh.2016.12.036
28. Barrett JS, Irving PM, Shepherd SJ, Muir JG, Gibson PR. Comparison of the prevalence of fructose and lactose malabsorption across chronic intestinal disorders. *Aliment Pharmacol Ther.* 2009;30:165–174. doi:10.1111/j.1365-2036.2009.04018.x
29. Owczarek D, Rodacki T, Domagała-Rodacka R, Cibor D, Mach T. Diet and nutritional factors in inflammatory bowel diseases. *World J Gastroenterol.* 2016;21–22(3):895–905. doi:10.3748/wjg.v22.i3.895
30. Godala M, Gaszyńska E, Zatorski H, Małecka-Wojcieszko E. Dietary interventions in inflammatory bowel disease. *Nutrients.* 2022;14(20):4261. doi:10.3390/nu14204261
31. Saha S, Patel N. What Should I Eat? Dietary Recommendations for patients with inflammatory bowel disease. *Nutrients.* 2023;15(4):896. doi:10.3390/nu15040896
32. Chicco F, Magri S, Cingolani A, Paduano D, et al. Multidimensional impact of Mediterranean Diet on IBD patients. *Inflamm. Bowel Dis.* 2021;27(1):1–9. doi:10.1093/ibd/izaa097
33. Papada E, Amerikanou C, Forbes A, Kaliora AC. Adherence to Mediterranean diet in Crohn's disease. *Eur J Nutr.* 2020;59:1115–1121. doi:10.1007/s00394-019-01972
34. Obih C, Wahbeh G, Lee D, Braly K, et al. Specific carbohydrate diet for pediatric inflammatory bowel disease in clinical practice within and academic IBD center. *Nutrition.* 2016;32(4):418–425. doi:10.1016/j.nut.2015.08.025
35. Lewis JD, Sandler RS, Brotherton C, Brensinger C, et al. DINE-CD Study Group. A randomized trial comparing the specific carbohydrate diet to a Mediterranean diet in adults with Crohn's disease. *Gastroenterology.* 2021;161:837–852.e9. doi:10.1053/j.gastro.2021.05.047
36. Limketkai BN, Godoy-Brewer G, Parian AM, Noorian S, et al. Dietary Interventions for the Treatment of Inflammatory Bowel Diseases: An Updated Systematic Review and Meta-analysis. *Clin Gastroenterol Hepatol.* 2023;21(10):2508–2525. doi:10.1016/j.cgh.2022.11.026
37. Campmans-Kuijpers MJE, Dijkstra G. Food and Food Groups in Inflammatory Bowel Disease (IBD): The Design of the Groningen Anti-Inflammatory Diet (GrAID). *Nutrients.* 2021;25:13(4):1067. doi:10.3390/nu13041067
38. Jaramillo AP, Abaza A, Sid Idris F, Anis H, et al. Diet as an Optional Treatment in Adults With Inflammatory Bowel Disease: A Systematic Review of the Literature. *Cureus.* 2023;18:15(7):e42057. doi:10.7759/cureus.42057
39. de Oliveira AM, Lourenço TGB, Colombo APV. Impact of systemic probiotics as adjuncts to subgingival instrumentation on the oral-gut microbiota associated with periodontitis: A randomized controlled clinical trial. *J Periodontol.* 2022;93(1):31–44. doi:10.1002/JPER.21-0078
40. Deandra FA, Ketherin K, Rachmasari R, Sulijaya B, Takahashi N. Probiotics and metabolites regulate the oral and gut microbiome composition as host modulation agents in periodontitis: A narrative review. *Heliyon.* 2023;3(9):e13475. doi:10.1016/j.heliyon.2023.e13475
41. Preidis GA, Weizman AV, Kashyap PC, Morgan RL. AGA Technical Review on the Role of Probiotics in the Management of Gastrointestinal Disorders. *Gastroenterology.* 2020;159(2):708–738.e4. doi:10.1053/j.gastro.2020.05.060
42. Su GL, Ko CW, Bercik P, Falck-Ytter Y, Sultan S, Weizman AV, Morgan RL. AGA Clinical Practice Guidelines on the Role of Probiotics in the Management of Gastrointestinal Disorders. *Gastroenterology.* 2020;159(2):697–705. doi:10.1053/j.gastro.2020.05.059
43. Lourenço TGB, Spencer SJ, Alm EJ, Colombo APV. Defining the gut microbiota in individuals with periodontal diseases: an exploratory study. *J Oral Microbiol.* 2018;3;10(1):1487741. doi:10.1080/20002297.2018.1487741.
44. World Health Organization. Ten threats to global health in 2019. <https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019> (access: 2024.03.18).
45. Health Emergency Preparedness and Response Authority. HERA factsheet – HEALTH UNION: Identifying top 3 priority health threats https://health.ec.europa.eu/publications/health-factsheet-health-union-identifying-top-3-priority-health-threats_en?prefLang=pl (access: 2024.03.18).
46. Mathewson ND, Jenq R, Mathew AV, Koenigsnecht M, et al. Gut microbiome-derived metabolites modulate intestinal epithelial cell damage and mitigate graft-versus-host disease. *Nat Immunol.* 2016;17(5):505–513. doi:10.1038/ni.3400
47. Siddiqui R, Badran Z, Boghossian A, Alharbi AM, Alfahemi H, Khan NA. The increasing importance of the oral microbiome in periodontal health and disease. *Future Sci OA.* 2023;12;9(8):FSO856. doi:10.2144/fsoa-2023-0062
48. Ferrillo M, Giudice A, Migliario M, Renó F, et al. Oral–Gut Microbiota, Periodontal Diseases, and Arthritis: Literature Overview on the Role of Probiotics. *Inter J Mol Sci.* 2023;24(5):4626. <https://doi.org/10.3390/ijms24054626>
49. Minić I, Pejčić A, Bradić-Vasić M. Effect of the local probiotics in the therapy of periodontitis A randomized prospective study. *Int J Dent Hyg.* 2022;20(2):401–407. doi:10.1111/idh.12509
50. Kobayashi R, Kobayashi T, Sakai F, Hosoya T, Yamamoto M, Kurita-Ochiai T. Oral administration of *Lactobacillus gasseri* SBT2055 is effective in preventing Porphyromonas gingivalis-accelerated periodontal disease. *Sci Rep.* 2017;3;7(1):545. doi:10.1038/s41598-017-00623-9
51. Singh D, Khan MA, Siddique HR. Therapeutic implications of probiotics in microbiota dysbiosis: A special reference to the liver and oral cancers. *Life Sci.* 2021;15(285):120008. doi:10.1016/j.lfs.2021.120008
52. Choi Y, Park E, Kim S, Ha J, et al. Fermented milk with *Lactobacillus curvatus* SMFM2016-NK alleviates periodontal and gut inflammation, and alters oral and gut microbiota. *J Dairy Sci.* 2021;104(5):5197–5207. doi:10.3168/jds.2020-19625
53. Kong C, Yan X, Liu Y, Huang L, et al. Ketogenic diet alleviates colitis by reduction of colonic group 3 innate lymphoid cells through altering gut microbiome. *Sig Transduct Target Ther.* 2021;6:154. <https://doi.org/10.1038/s41392-021-00549-9>
54. Li S, Zhuge A, Wang K, Lv L, Bian X, Yang L, et al. Ketogenic diet aggravates colitis, impairs intestinal barrier and alters gut microbiota and metabolism in DSS-induced mice. *Food Funct.* 2021;19;12(20):10210–10225. doi:10.1039/d1fo02288a

55. Gubatan J, Kulkarni CV, Talamantes SM, Temby M, Fardeen T, Sinha SR. Dietary Exposures and Interventions in Inflammatory Bowel Disease: Current Evidence and Emerging Concepts. *Nutrients*. 2023;15(3):579. <https://doi.org/10.3390/nu15030579>
56. Paoli A, Moro T, Bosco G, Bianco A, Grimaldi KA, Camporesi E, Mangar D. Effects of n-3 Polyunsaturated Fatty Acids (ω -3) Supplementation on Some Cardiovascular Risk Factors with a Ketogenic Mediterranean Diet. *Marine Drugs*. 2015;13(2):996–1009. <https://doi.org/10.3390/md13020996>
57. Rondanelli M, Perna S, Ilyas Z, Peroni G, Bazire P, Sajuox I, et al. Effect of very low-calorie ketogenic diet in combination with omega-3 on inflammation, satiety hormones, body composition, and metabolic markers. A pilot study in class I obese subjects. *Endocrine*. 2022;75(1):129–136. doi:10.1007/s12020-021-02860-5
58. Ho SM, Lewis JD, Mayer EA, Plevy SE, et al. Challenges in IBD Research: Environmental Triggers. *Inflamm. Bowel Dis.* 2019;16;25(Suppl 2):S13–S23. doi:10.1093/ibd/izz076
59. Rizzello F, Spisni E, Giovanardi E, Imbesi V, et al. Implications of the Westernized Diet in the Onset and Progression of IBD. *Nutrients*. 2019;8;11(5):1033. doi:10.3390/nu11051033
60. Kreła-Kaźmierczak I, Zakerska-Banaszak O, Skrzypczak-Zielińska M, Łykowska-Szuber L, A et al. Where Do We Stand in the Behavioral Pathogenesis of Inflammatory Bowel Disease? The Western Dietary Pattern and Microbiota-A Narrative Review. *Nutrients*. 2022;17;14(12):2520. doi:10.3390/nu14122520
61. Guan Q. A Comprehensive Review and Update on the Pathogenesis of Inflammatory Bowel Disease. *J Immunol Res.* 2019 1;2019:7247238. doi:10.1155/2019/7247238
62. Dolan KT, Chang EB. Diet, gut microbes, and the pathogenesis of inflammatory bowel diseases. *Mol Nutr Food Res.* 2017;61(1):10.1002/mnfr.201600129. doi:10.1002/mnfr.201600129
63. Schwärzler J, Mayr L, Vich Vila A, Grabherr F, et al. PUFA-Induced Metabolic Enteritis as a Fuel for Crohn's Disease. *Gastroenterology*. 2022;162(6):1690–1704. doi:10.1053/j.gastro.2022.01.004
64. Rinninella E, Raoul P, Cintoni M, Franceschi F, et al. What is the Healthy Gut Microbiota Composition? A Changing Ecosystem across Age, Environment, Diet, and Diseases. *Microorganisms*. 2019;10;7(1):14. doi:10.3390/microorganisms7010014
65. Niewiadomski O, Studd C, Wilson J, Williams J, et al. Influence of food and lifestyle on the risk of developing inflammatory bowel disease. *Intern Med J.* 2016;46:669–676. doi:10.1111/imj.13094
66. Cao Y, Liu H, Qin N, Ren X, et al. Impact of food additives on the composition and function of gut microbiota: A review. *Trends Food Sci Technol.* 2020;99:295–310. <https://doi.org/10.1016/j.tifs.2020.03.006>
67. Xu Y, Luo J, Gao Y, Tao Y, Xu J, Yao T, Chen Y. Causal effects between inflammatory bowel disease and oral diseases based on Oral-GUT Axis: a Mendelian randomization study. *Nutrients* 2023;15(20):4445 <https://doi.org/10.3390/nu15204445>
68. Byrd KM, Gulati AS. The “Gut-Gut” Axis in Inflammatory Bowel Diseases: A Hypothesis-Driven Review of Associations and Advances. *Front Immunol.* 2021 Feb 19;12:620124. doi:10.3389/fimmu.2021.620124. PMID:33679761; PMCID:PMC7933581
69. Virk MS, Virk MA, He Y, Tufail T, et al. The Anti-Inflammatory and Curative Exponent of Probiotics: A Comprehensive and Authentic Ingredient for the Sustained Functioning of Major Human Organs. *Nutrients*. 2024;16(4):546. <https://doi.org/10.3390/nu16040546>