The Importance of Dietary Fiber in Managing Metabolic Syndrome

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Abstract

The rise of metabolic syndrome and related non-communicable diseases (NCDs) presents a significant public health challenge, particularly in Georgia, where the prevalence of complications such as type 2 diabetes is notably high. Dietary fiber plays a crucial role in addressing these health issues by enhancing insulin sensitivity, regulating blood glucose levels, managing lipid profiles, and reducing body mass index (BMI) and waist circumference (WC). The Georgian product "Margi" provides a valuable solution by utilizing a patented processing method to convert wheat bran into a hydrophilic and easily digestible form, thereby enhancing its nutritional benefits. By incorporating "Margi" into daily diets, individuals can increase their fiber intake in alignment with World Health Organization recommendations. This strategy not only supports the management of metabolic syndrome but also fosters healthier dietary habits and improves public health outcomes in Georgia.

Keywords: Metabolic syndrome, hemicellulose, Foods rich in fiber.

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Introduction.

The challenges of the 21st century significantly impact human physical, moral, social and spiritual development which in turn leads to an increase in non-communicable diseases (NCDs) of civilization [1]. Obesity, metabolic syndrome, insulin resistance, and type 2 diabetes have become non-infectious epidemics. According to statistical analysis, civilization-related non-communicable diseases are more common in countries where populations consume high-calorie foods rich in refined carbohydrates and fats, while lacking in plant-based fiber. Modern medicine has proven powerless in the face of the

widespread threat posed by these diseases [2].

Metabolic disorders—including insulin resistance, arterial hypertension, dyslipidemia, and obesity—represent one of the leading public health challenges globally, affecting between 20% and 40% of the adult population [3]. The prevalence varies depending on demographic and geographic factors. In Western European countries, the prevalence of metabolic syndrome ranges from 20% to 30% while in Eastern Europe, it exceeds 40%. Scandinavian countries report lower prevalence rates between 15% and 25%. In the United States, one in three adults is affected by metabolic syndrome [5].

In Georgia, although the percentage of metabolic syndrome cases appears relatively low, many cases remain undiagnosed during the early stages of metabolic disorders. However, complications such as type 2 diabetes are more commonly detected. According to data from the National Center for Disease Control and Public Health, as of the end of 2021, Georgia registered 74,305 patients with type 2 diabetes, with a prevalence rate of 2,003.5 per 100,000 population [6]. The widespread unhealthy lifestyle, poor dietary habits, and insufficient level of preventive medicine in Georgia form the basis for an unfavorable prognosis.

Metabolic syndrome is a cluster of conditions that increases the risk of serious health complications, such as coronary heart disease, diabetes and stroke. The conditions associated with metabolic syndrome include abdominal obesity, elevated blood pressure, high fasting blood glucose levels, increased triglyceride levels and low levels of high-density lipoproteins (HDL). The presence of three or more of these criteria is sufficient to diagnose metabolic syndrome [7].

Managing metabolic syndrome is a significant burden on a country's healthcare system and economy. However, a preventive approach can substantially reduce the risk of disease development. This approach involves making lifestyle changes, improving dietary habits, increasing physical activity and implementing pharmacotherapy when it is necessary.

Insulin resistance often serves as a precursor in the development of metabolic syndrome. It is a pathological condition when the cells of insulin-sensitive tissues in the body do not respond normally to the hormone insulin or the number of insulin-sensitive receptors decreases in response to hyperinsulinemia [8]. Genetic and epigenetic factors, dysfunction of adipose tissue, age, various medications, rare diseases and environmental factors all contribute to the development of Insulin resistance. In its early stages, this condition may be asymptomatic. However, it ultimately plays a significant role in the development of metabolic syndrome, cardiovascular diseases (CVD), non-alcoholic fatty liver disease (NAFLD), polycystic ovary syndrome (PCOS) and type 2 diabetes (T2D). Consequently, the early diagnosis and proper management of insulin resistance can reduce the risk of complications associated with metabolic disorders like diabetes. For example 11% of patients with prediabetes will develop type 2 diabetes within 3years [9].

The HOMA- index (Homeostasis Model Assessment) is used to assess insulin resistance and is calculated using the formula (fasting blood glucose x fasting insulin) / 22.5. A HOMA IR > 1.4 is considered abnormal. The laboratory analysis is performed in the morning while fasting (at least 8 hours should have passed since the last meal) and the sample should consist of venous blood.

From a treatment perspective, it is important to identify risk factors and implement early interventions in lifestyle and/or pharmacotherapy. All approaches aimed at increasing insulin sensitivity play a significant role in managing and preventing complications associated with insulin resistance [10].

Long-term structured programs, including dietary fibers, specific food choices and increased in physical activity are effective strategies for managing metabolic conditions [11]. However, maintaining behavioral changes, managing food relationships and adhering to dietary recommendations require strong willpower and discipline. Numerous studies have explored the effectiveness of low-glycemic index diets in the context of metabolic syndrome. Additionally, enriching the daily diet with dietary fiber interventions is also important. This approach represents one of the more sustainable and effective ways to maintain a

diet. The World Health Organization (WHO), the European Association for the Study of Diabetes (EASD), the American Diabetes Association (ADA), the American Heart Association (AHA), and the Georgian Association for the Study of Obesity unanimously recommend lifestyle modifications and a fiber-rich diet. According to these recommendations, a daily intake of 25-38 grams of dietary fiber is necessary. However, the average intake is below the recommended level at just 14 grams. Furthermore, when implementing dietary interventions, it is essential to consider the country's religious, economic, and social conditions, as well as gastronomic culture, gender, ethnicity and age [12-15].

Dietary fibers are classified based on their solubility in water into two categories: soluble and insoluble fibers. Soluble fibers include pectins, glycosaminoglycans, inulin and certain water-soluble hemicelluloses. Insoluble fibers mainly consist of lignin, cellulose, and hemicellulose[16].

Various studies have shown the positive impact of soluble fibers on insulin resistance and lowering blood sugar levels in patients with type 2 diabetes [17]. The mechanism is associated with their viscosity and effects on digestive enzymes, which influence the absorption rates of glucose and lipids. As for insoluble dietary fibers, wheat bran is particularly rich with them (for example: 100 grams of wheat bran contains 43 grams of fiber, while 100 grams of rice bran contains 21 gramsand oats contain 15 grams of fiber). This clearly indicates the superiority of wheat as a source of dietary fiber. Insoluble fibers are low in calories but high in volumewhich helps promote a feeling of fullness and prevents overeating, making them potentially beneficial for weight management.

A meta-analysis of epidemiological studies has shown that the inclusion of dietary fiber in daily diets leads in a reduction in body mass index (BMI) and waist circumference (WC). Additionally, Dietary-Fiber has documented effects on hormone secretion (such as CKC, PPY, and GLP-1) , suppresses ghrelin production and promotes satiety [18].

The prebiotic properties of dietary fibers and the development of beneficial gut microbiota, along with the production of secondary metabolites, help reduce inflammatory responses. Additionally, the antioxidant components of insoluble fibers decrease oxidative stress, restore the activity of antioxidant enzymes, and inhibit oxidative damage to pancreatic β-cells – a know risk factor for development of diabetes [19].

Based on the review of existing publications, research and epidemiological studies, we can conclude that cereal fiber has the following effects [20, 21]:

➢ It regulates blood glucose levels by slowing absorption and improves tissue sensitivity to insulin.

➢ Foods rich in fiber are often low in calories but high in volume, which promotes a feeling of fullness and helps prevent overeating, potentially benefiting weight management.

➢ Fiber acts as a prebiotic. A healthy gut microbiome is associated with better blood glucose control and overall metabolic health.

➢ High-fiber diets help regulate cholesterol levels, which contributes to reducing the risk of cardiovascular diseases.

➢ Fiber may lead to reduced oxidative stress, improved insulin sensitivity, vascular protection, and modulation of inflammation, all of which are significant factors in managing and preventing metabolic disorders and their associated complications.

Whole grain products are a readily available and rich source of dietary fiber. The term "whole grain" refers to products made from milled or otherwise processed grains that retain all anatomical components, including the endosperm, germ and bran. These components should be present in the same relative proportions as they are in the intact grain. It is important to note that antioxidant compounds are primarily concentrated in the outer layers of the grain. Therefore, bran serves as a universal source of these beneficial substances [21]. Its antioxidant properties are largely attributed to the presence of phenolic acid derivatives, with up to 80% of these compounds concentrated in the outer layers of rye and wheat. Both

wheat and rye are also characterized by their content of cinnamic acid derivatives and alkylresorcinols. Grain bran also contains polyphenolic compounds (such as lignans and flavonoids), tocopherols, carotenoids, phytic acid, and metal ions (including iron, zinc, copper, and selenium), which exhibit antioxidant activity as well as other macro and micronutrient benefits.

However, hydrophobic bran can irritate the intestinal mucosa without chemical processing. The refinement process of grains removes vital nutrients, dietary fibers, and other phytonutrients[22]. Therefore, it is necessary to process the bran into a product that transforms hydrophobic coarse bran into hydrophilic products while retaining all of its beneficial properties. Therefore, the form of dietary fiber delivery and the use of innovatively processed products containing dietary fiber are of great importance. Foods containing this processed fiber are marketed in Georgia under the brand name "Marg" The processing method is patented both in Georgia and abroad, including a granted FDA patent (PCT/GE2007/000003). According to this method, wheat bran, which is the richest source of dietary fiber, undergoes initial mechanical, chemical, and thermal processing outside the body. The wheat bran included in "Margi" products is pre-processed in a way that mimics human digestion, resulting in the dietary fiber losing its coarseness, becoming hydrophilic, and retaining all the beneficial properties characteristic of dietary fiber. As a result, the nutritional properties of the product are enhanced, positively impacting the gastrointestinal tract and the entire body. The product's gastro-nutritional value includes: dietary fiber 9.4 g, carbohydrates 36.06 g, fats 0.94 g, proteins 6.41 g, and 172 kJ [23].

A healthy lifestyle and dietary intervention is a long-term commitment that requires attention to various specific factors. Wheat products, as one of the oldest and most significant elements of Georgian gastronomic culture, play a crucial role in this process. Thus, incorporating dietary fiber interventions through "Margi" products will not only be effective and accessible but also align with sustainable practices. This approach has the potential to enhance overall health and well-being within the community, making it a worthwhile endeavor for promoting healthier living.

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