Chapter

Principles of Nutrition in Patients with Non-alcoholic Fatty Liver Disease

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Abstract

This chapter will comprehensively address the nutritional principles essential for managing nonalcoholic fatty liver disease (NAFLD). It will explore the critical role of diet in the prevention and treatment of NAFLD, providing evidence-based dietary recommendations to improve liver health and the overall well-being of patients. Key topics will include the importance of balanced macronutrient intake, the role of specific nutrients and food groups (e.g., antioxidants, fiber, and healthy fats), and the impact of dietary patterns such as the Mediterranean and Dietary Approaches to Stop Hypertension (DASH) diet on liver fat reduction and inflammation. Additionally, the chapter will discuss the significance of weight management, outlining the standard amount of weight loss beneficial for NAFLD patients. Practical guidelines on how to implement these dietary changes, overcome common barriers, and maintain long-term adherence will be provided. This chapter aims to equip healthcare professionals and patients with the knowledge and tools necessary to effectively manage NAFLD through diet, ultimately improving patient outcomes and quality of life.

Keywords: nonalcoholic fatty liver disease, NAFLD, dietary intervention, Mediterranean diet, DASH diet

1. Introduction

Nonalcoholic fatty liver disease (NAFLD) is characterized by excessive hepatic fat accumulation in individuals with minimal or no alcohol consumption. This condition results from a combination of pathological factors and lifestyle choices, often arising primarily from metabolic imbalances and unhealthy habits rather than traditional risk factors. As a metabolic disease, NAFLD is closely linked to poor dietary practices, sedentary behavior, and obesity [1, 2].

Management of NAFLD centers on lifestyle modification, encompassing dietary changes, increased physical activity, and weight reduction. Evidence suggests that a 5–7% weight loss can improve hepatic steatosis, while a loss exceeding 10% is recommended for ameliorating fibrosis and inflammation. Studies indicate that a 7–10% reduction in initial body weight leads to improvements in liver enzymes and histological changes in overweight and obese NAFLD patients [2, 3].

Physical activity plays a crucial role in NAFLD management. Guidelines recommend 150–200 minutes of exercise per week, spread across 3–5 days. Both aerobic and resistance training have shown benefits in improving NAFLD outcomes [1, 2, 4].

Dietary interventions focus on calorie restriction, typically 500–1000 kcal below daily requirements, though some sources suggest a 350–750 kcal reduction may suffice. The diet should minimize high-calorie, processed foods and emphasize vegetables, fruits, whole grains, lean proteins, and healthy fats [1–3, 5].

Understanding the specific contributions of macronutrients is essential for developing effective dietary strategies for NAFLD. The following sections delve into the recommended intake and key considerations for macronutrients in the context of NAFLD management. This detailed examination of macronutrients provides the foundation for understanding specific dietary approaches that have shown promise in NAFLD treatment.

We will then explore two dietary patterns that have demonstrated particular efficacy in managing NAFLD, integrating the principles of macronutrient balance with practical dietary recommendations. These dietary approaches offer comprehensive strategies for improving liver health through nutritional interventions, addressing both the quantity and quality of food intake.

While lifestyle modifications including physical activity and weight management can complement dietary interventions, the primary focus of this chapter will be on the crucial role of diet in NAFLD management, providing evidence-based nutritional strategies for improving liver health.

2. Carbohydrates consumption guidelines for NAFLD patients

The consumption of carbohydrates plays a significant role in the management and outcomes of NAFLD. The American Heart Association recommends that adults obtain 45–65% of their daily caloric intake from carbohydrates. In contrast, the Academy of Nutrition and Dietetics suggests that adults with NAFLD should derive 45–55% of their daily calories from carbohydrates [6]. For patients with NAFLD, it is essential that the carbohydrates consumed exhibit specific characteristics:

2.1 Low glycemic index (GI) and glycemic load (GL)

Carbohydrates with a low glycemic index (GI) and glycemic load (GL) lead to a slower, more gradual increase in blood glucose, as illustrated in **Figure 1**. This figure demonstrates how foods with different GI and GL values impact blood glucose and insulin levels over time. The glycemic index reflects how rapidly a food raises blood glucose, while the glycemic load considers both the quality (GI) and quantity of carbohydrates, providing a fuller picture of its effect. High-GI (≥70) and high-GL (≥20) foods, shown by the red curve, cause a sharp rise in blood glucose, peaking around 30 minutes post-ingestion. This rapid increase triggers a significant insulin response, which then quickly lowers glucose levels, sometimes below baseline, potentially causing reactive hypoglycemia. This response is common in refined or processed carbohydrates, which are rapidly absorbed. Medium-GI (56–69) and medium-GL (11–20) foods, represented by the yellow curve, produce a more moderate rise in glucose and insulin levels, with a lower peak and slower return to baseline. This intermediate response is typical of foods with a balanced carbohydrate composition, providing a sustained glucose supply and avoiding extreme fluctuations. Low-GI (≤55) and

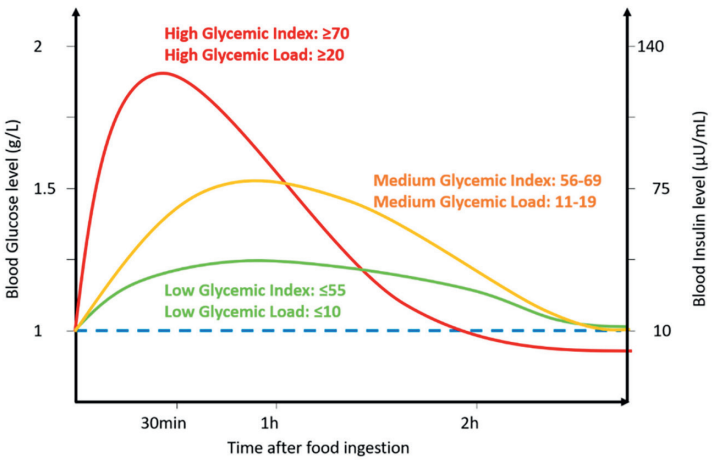

Figure 1.
Blood glucose and insulin responses to foods with varying glycemic indices and glycemic loads. Source: Adapted from Carneiro L, Leloup C. "Mens sana in corpore sano: Does the Glycemic Index Have a Role to Play?" Nutrients, 2020. Reproduced with permission [7].

low-GL (≤10) foods, illustrated by the green curve, minimally impact blood glucose and insulin levels. The gradual increase and prolonged glucose availability are characteristic of high-fiber and complex carbohydrate foods, which help stabilize blood glucose and minimize excessive insulin release, supporting metabolic health [7].

To achieve these benefits, it is recommended to choose whole grains over refined grains, increase intake of vegetables and fruits, use legumes as both protein and carbohydrate sources, and limit consumption of simple sugars and processed foods.

2.2 High-fiber content

Fiber-rich carbohydrates play a crucial role in managing NAFLD by slowing down the digestion and absorption of sugars. This slower digestion process promotes feelings of fullness, which can be beneficial for weight management. Soluble fiber, in particular, is effective in reducing liver fat accumulation. Excellent sources of fiber-rich carbohydrates include oats, barley, fruits, vegetables, and legumes. Incorporating these foods into the diet can support overall health and contribute to better management of NAFLD.

2.3 Complex carbohydrates

Complex carbohydrates are preferable to simple sugars because they provide sustained energy and are less likely to be converted to fat in the liver. This makes them a beneficial choice for individuals seeking to maintain stable energy levels and support liver health. However, it's important to note that the relationship between carbohydrates and liver health is complex and multifaceted. Recent research has shown that carbohydrates are positively correlated with inflammation, which can increase lipid deposition through multiple pathways. This finding may explain why some patients with NAFLD experience worsening conditions after switching to a 'vegetarian' diet that is often high in carbohydrates [8]. Examples of complex carbohydrates include whole grains, brown rice, and quinoa, all of which can be effectively incorporated into a balanced diet to promote overall well-being.

2.4 Minimal added sugars

Reducing the intake of added sugars is crucial for patients with NAFLD, as high sugar consumption is linked to increased liver fat accumulation and inflammation. A significant contributor to this risk is the consumption of foods and beverages sweetened with high-fructose corn syrup (HFCS), which is known to stimulate de novo lipogenesis, leading to the development and progression of NAFLD [1, 9, 10]. Fructose, a component of HFCS, bypasses the major rate-limiting step of glycolysis, promoting hepatic fat accumulation and inflammation [10]. To mitigate these risks, it is advisable to avoid or limit foods with added sugars, such as sodas, candies, and processed snacks, particularly those containing HFCS. By minimizing the consumption of these sugars, individuals with NAFLD can better manage their condition and support liver health [9–11].

2.5 Rich in antioxidants

Carbohydrate sources rich in antioxidants play a crucial role in mitigating oxidative stress and inflammation in the liver, both of which are key factors in the progression of NAFLD. The significance of antioxidants in managing NAFLD is intricately linked to the complex interplay between reactive oxygen species (ROS), inflammation, and lipid metabolism within the liver. ROS are generated from various cellular sources, including the mitochondrial respiratory chain, cytochrome P450 system (CYP450), and NADPH oxidase complex. When present in excess, ROS can lead to oxidative stress. In inflammatory conditions, immune cells release large quantities of reactive oxygen radicals, which can potentially cause chronic inflammation if healthy tissues are not reconstructed in a timely manner. This chronic inflammation, which may be triggered by high intake of starchy carbohydrates, perpetuates the activation of inflammatory mediators such as NF-κB, thereby sustaining the inflammatory cycle. The oxidative stress induced by elevated ROS levels can result in apoptosis and necrosis of liver cells. Moreover, ROS can initiate chain reactions between free radicals and unsaturated fatty acids, forming toxic lipid intermediates that exacerbate liver damage. Additionally, carbohydrates may activate ROS through CYP enzymes, further aggravating lipid metabolism disorders due to oxidative stress. Given these mechanisms, consuming a diet rich in antioxidants is essential for individuals managing NAFLD. Colorful fruits and vegetables are excellent sources of antioxidants that can help alleviate the effects of oxidative stress and support liver health. Incorporating a variety of antioxidant-rich foods into the diet provides a range of beneficial compounds that work through different mechanisms to combat oxidative stress and inflammation. These compounds may include vitamins C and E, carotenoids, flavonoids, and other polyphenols found in fruits, vegetables, nuts, and whole grains [8].

3. Fruits consumption guidelines for NAFLD patients

Fruits play a significant role in the dietary management of NAFLD. When selecting fruits for a food basket aimed at patients with NAFLD, several characteristics should be considered:

3.1 Key characteristics of fruits for NAFLD patients

3.1.1 Low sugar content

While fruits are generally healthy, those with lower sugar levels are preferable for individuals with NAFLD. Excessive sugar intake can exacerbate liver fat accumulation. Fruits like berries (strawberries, blueberries) and citrus fruits (lemons, limes) are lower in sugar compared to tropical fruits like bananas and mangoes. This is particularly important as high fructose intake increases hepatic de novo lipogenesis (DNL), reduces fatty acid β-oxidation (FAO), and leads to fatty acid deposition [12, 13].

3.1.2 High antioxidant content

Fruits rich in antioxidants, such as polyphenols and flavonoids, can help reduce oxidative stress and inflammation associated with NAFLD. Examples include apples, grapes, and cherries, which have been noted for their beneficial phytoconstituents. These antioxidants, including vitamin C, vitamin E, beta-carotene, and polyphenols, neutralize free radicals and mitigate the detrimental effects of oxidative stress on the liver. The anti-inflammatory properties of these compounds are crucial in alleviating NAFLD symptoms, as the condition is frequently accompanied by an inflammatory response [12, 13].

3.1.3 Anti-inflammatory properties

Certain fruits possess anti-inflammatory properties that can be beneficial for liver health. Berries, for example, are known to have compounds that may help modulate inflammatory pathways. The polyphenols and flavonoids found in fruits can reduce the severity of inflammation in the liver. This is particularly important as NAFLD is often associated with chronic inflammation, and inhibiting this inflammation is crucial to managing the condition [12, 13].

3.1.4 Fiber-rich

Fruits that are high in dietary fiber can aid in digestion and help maintain a healthy weight, which is crucial for managing NAFLD. Apples, pears, and raspberries are excellent sources of fiber. Dietary fiber, abundant in fruits, is a type of short-chain fatty acid (SCFA) produced by the fermentation of intestinal microorganisms. These SCFAs have numerous benefits, including maintaining the integrity of the intestinal barrier, reducing inflammatory reactions in the liver, regulating appetite, and maintaining glucose balance at the systemic level. Furthermore, dietary fiber enhances satiety, thus promoting calorie restriction [12].

3.1.5 Bioactive compounds

Fruits containing bioactive compounds such as catechins, resveratrol, and other phytochemicals may help in improving liver health by enhancing lipid metabolism and reducing fat accumulation in the liver. Examples include grapes, berries, apples,

citrus fruits, and cherries. These bioactive compounds have been shown to have various beneficial effects on liver health, including improving insulin sensitivity and regulating liver lipid metabolism [12, 13].

3.1.6 Moderation in consumption

While fruits are healthy, moderation is key. Studies suggest that excessive fruit consumption (more than four servings per day) may exacerbate liver steatosis and dyslipidemia in patients with NAFLD. This is because fruits contain natural fructose, and high fructose intake can promote the development of NAFLD. It's important to note that the effects of fruit consumption may vary between individuals and populations. For instance, some studies have found differences in the relationship between fruit intake and NAFLD prevalence between males and females, which may be attributed to differences in dietary patterns and metabolic processes [12, 13].

3.2 Recommended fruits

Berries: Strawberries, blueberries, and blackberries.
Citrus fruits: Oranges, lemons, and grapefruits.
Apples: Particularly with the skin for added fiber.
Pears: High in fiber and low in sugar.
Grapes, Pomegranates: Contain beneficial antioxidants.

4. Vegetable consumption guidelines for NAFLD patients

Vegetable consumption is crucial for individuals with NAFLD due to their rich nutrient profile and low-calorie content. Vegetables provide essential fiber and antioxidants, which help regulate blood sugar, reduce liver fat accumulation, and combat oxidative stress and inflammation. Incorporating a variety of non-starchy vegetables into the diet can significantly support liver health and overall well-being in NAFLD patients. Patients with nonalcoholic fatty liver disease should aim for a daily intake of four to five servings of non-starchy vegetables, totaling at least 500 grams per day [14]. This intake helps manage blood sugar levels, reduces fat accumulation in the liver, and provides essential nutrients [13–15].

4.1 Types of vegetables

4.1.1 Non-starchy vegetables (recommended)

Examples include artichoke, asparagus, baby corn, bell peppers, beets, Brussels sprouts, broccoli, cabbage, carrots, cauliflower, celery, chayote, cucumber, eggplant, leeks, okra, radishes, salad greens, spinach, turnips, tomato, and zucchini. These vegetables are low in calories and carbohydrates but high in essential nutrients and fiber [15].

4.1.2 Starchy vegetables (limit consumption)

Examples: Beans (black, kidney, navy, andpinto), butternut squash, cassava, chickpeas, corn, lentils, peas, sweet potatoes, vegetable juices, white potatoes, and yams.

4.2 Key recommendations

4.2.1 High-fiber vegetables

Leafy greens like spinach, kale, and lettuce are excellent choices for improving digestive health and aiding in weight management, which are crucial factors in NAFLD management [14, 15].

4.2.2 Antioxidant-rich vegetables

Consuming broccoli and other antioxidant-rich vegetables can help reduce inflammation and oxidative stress in the liver, potentially slowing the progression of NAFLD [16].

4.2.3 Preparation methods

To maximize nutrient benefits, it's recommended to eat vegetables in their whole form. This can include raw, roasted, sautéed, grilled, blanched, or in soups. These methods help preserve the nutritional value of the vegetables [16].

4.2.4 Vegetables to avoid

It's advisable to limit or avoid fried vegetables, such as french fries and potato chips. These foods are high in unhealthy fats and can contribute to liver fat accumulation and inflammation, potentially worsening NAFLD [16].

5. Protein consumption guidelines for patients with NAFLD

Managing NAFLD requires careful attention to dietary choices, particularly regarding protein intake. This guide outlines essential recommendations for protein consumption to support liver health and overall well-being.

5.1 Key recommendations

5.1.1 Balanced protein intake

For individuals with NAFLD, a daily protein intake of 1.0 to 1.2 grams per kilogram of ideal body weight is advisable, which can vary based on personal health and activity levels [17]. To calculate daily protein requirements more accurately, several factors should be considered: Age, gender, height, weight, activity level, health goals. Online tools and specialized applications can assist in this calculation by taking these factors into account. These resources provide a more precise estimate of an individual's protein needs, offering valuable guidance for those managing NAFLD or other health conditions.

It is important to note that while these calculators offer helpful insights, they should be used as general guidelines. For personalized nutritional advice, especially for those with NAFLD, consultation with a registered dietitian or healthcare professional is recommended.

5.1.2 Quality of protein sources

Plant-based proteins: Prioritize legumes (beans, lentils, chickpeas), tofu, tempeh, and quinoa. These options are not only rich in protein but also high in fiber, promoting digestive health [17].

Lean animal proteins: Include chicken, turkey, and fish (especially fatty varieties like salmon and mackerel). These sources are lower in saturated fats, making them more suitable for liver health [17, 18].

Dairy: Incorporate low-fat or fat-free dairy products such as yogurt, milk, and cheese, which can also contribute to protein intake [17].

5.1.3 Limit certain proteins

Reduce consumption of red meat and processed meats (like bacon, sausages, and deli meats) due to their high saturated fat content, which can worsen liver inflammation [17].

5.1.4 Balancing nutrients

Ensure protein intake is complemented with healthy fats (from nuts, seeds, avocados, and olive oil) and complex carbohydrates (such as whole grains, fruits, and vegetables) [18–20].

Avoid diets excessively high in protein that may neglect other essential nutrients, as this can place additional stress on the liver [19].

5.1.5 Weight management considerations

For those aiming to lose weight, protein can be beneficial in preserving muscle mass while reducing fat [21]. Additionally, dietary modifications, such as following a Mediterranean diet rich in fruits, vegetables, whole grains, and olive oil, have been associated with improved outcomes in NAFLD patients. Considering the multifactorial nature of NAFLD, personalized dietary approaches tailored to individual preferences and needs are crucial for successful weight management and overall disease management [22].

5.1.6 Avoid excessive protein intake

Extremely high-protein diets, particularly those focusing heavily on animal proteins, should be avoided to prevent increased liver workload and potential health complications [18].

For patients with NAFLD, a balanced approach to protein consumption is crucial. Emphasizing plant-based proteins and lean animal sources while limiting red and processed meats can significantly contribute to liver health. Ongoing research is essential to refine these guidelines and further understand the impact of specific amino acids on NAFLD management.

6. Dairy consumption guidelines for NAFLD patients

The role of dairy products in NAFLD management has been a subject of research, with mixed findings. However, recent studies and guidelines suggest that moderate dairy consumption can be part of a healthy diet for individuals with NAFLD.

6.1 Key recommendations

6.1.1 Type of dairy matters

Research indicates that the type of dairy consumed matters significantly, with full-fat dairy products potentially increasing the risk of metabolic syndrome and NAFLD, while low-fat or fat-free dairy products may offer protective effects [23, 24].

6.1.2 Potential benefits of low-fat dairy

Improved insulin sensitivity: Low-fat dairy products are rich in calcium, magnesium, and high-quality proteins, which can help improve insulin sensitivity, a key factor in NAFLD development and progression [25].

Weight management: Dairy products, especially those low in fat, can help with weight management by increasing satiety and reducing overall calorie intake [26].

Reduced inflammation: fermented dairy products containing probiotics, such as lactic acid bacteria and bifidobacteria, have been associated with various health benefits, including improved glucose homeostasis and inflammatory markers, which are essential for managing conditions like diabetes and obesity [23].

6.1.3 Guidelines and recommendations

The American Association for the Study of Liver Diseases (AASLD) does not have specific dairy recommendations for NAFLD patients but supports a balanced diet that includes low-fat or fat-free dairy products as part of an overall strategy for weight management and metabolic health [27].

The Dietary Approaches to Stop Hypertension (DASH) diet and the Mediterranean diet are two well-known dietary regimens that, in addition to emphasizing the consumption of fruits, vegetables, whole grains, and low-calorie foods, also focus on low-fat dairy products. According to research findings, these diets have resulted in improved liver enzymes and reduced hepatic steatosis (fat accumulation in the liver), and favorable changes in oxidative stress biomarkers in overweight and obese patients with NAFLD [28, 29].

6.2 Individual considerations

When recommending dairy products for patients with NAFLD, it is crucial to consider individual factors such as lactose intolerance, dairy allergies, and personal preferences. Lactose-hydrolyzed dairy products and plant-based milk alternatives are becoming popular options for those with lactose intolerance and dairy allergies, respectively [30, 31]. The development of lactose-free dairy products, like lactose-free albumin from whey, provides alternatives rich in amino acids and high digestibility. Understanding consumer preferences, availability, quality, and health consciousness is essential when making dairy product recommendations [32]. By considering these individual factors and the diverse range of dairy alternatives available, tailored recommendations can be made to meet the specific needs and preferences of each patient with NAFLD.

In conclusion, moderate consumption of low-fat or fat-free dairy products can be part of a healthy diet for individuals with NAFLD, potentially offering benefits for insulin sensitivity, weight management, and inflammation. However, it's essential to

tailor dietary recommendations to each patient's specific needs and preferences, and to consider them as part of a comprehensive approach to managing NAFLD, which includes regular physical activity, weight loss if overweight or obese, and management of other metabolic risk factors.

7. Fat consumption guidelines for NAFLD patients

Contrary to common belief, not all dietary fats are detrimental for those with NAFLD. In fact, certain fats can promote liver health. It's important to differentiate between various types of fats and their respective effects on the liver.

7.1 Types of fats and their implications

7.1.1 Saturated fats

Commonly found in animal products like red meat and dairy, as well as some plant oils (e.g., coconut and palm oil), saturated fats can exacerbate liver fat accumulation and inflammation [33, 34]. Moreover, studies highlight the association between the consumption of foods high in saturated fat content and the increasing prevalence of obesity, which is closely related to NAFLD and other metabolic disorders like insulin resistance and fatty liver disease [35, 36]. Therefore, individuals with NAFLD should limit their intake of these fats.

7.1.2 Trans fats

These unhealthy fats are typically present in processed foods and baked goods. Trans fats are produced through hydrogenation and have a negative impact on liver function [6, 37]. It is advisable to eliminate them from the diet entirely.

7.1.3 Monounsaturated fats

Monounsaturated Fats (MUFAs) are present in foods such as olive oil, avocados, nuts, and seeds. These fats can enhance liver enzyme levels and decrease liver fat, making them beneficial additions to your diet [6, 37]. The Mediterranean diet, renowned for its health benefits, emphasizes the consumption of MUFAs. Foods rich in MUFAs, such as olive oil, nuts, and seeds, play a crucial role in providing these healthy fats, which can improve liver enzyme levels and reduce liver fat.

7.1.4 Polyunsaturated fats

Polyunsaturated Fats (PUFAs): Found in fatty fish (like salmon and mackerel), flaxseed oil, and walnuts, PUFAs, especially omega-3 fatty acids, are known for their anti-inflammatory properties and support liver health [6, 37].

7.2 Key recommendations

7.2.1 Minimize saturated and trans fats

Cut back on red meat and processed foods. Opt for lean proteins, such as poultry and fish, to reduce fat intake that can harm liver health [6].

7.2.2 Incorporate MUFAs

Add healthy fats like olive oil, avocados, nuts, and seeds to your meals. Use olive oil for cooking and as a dressing for salads [6].

7.2.3 Focus on omega-3 fatty acids

Aim to eat fatty fish at least twice weekly. If fish is not a regular part of your diet, consider flaxseed oil or algae-based omega-3 supplements [6].

7.2.4 Moderate total fat intake

Recommendations for NAFLD patients suggest that fat intake should be less than 30% of daily calories, with an emphasis on increasing consumption of foods rich in mono- and polyunsaturated fatty acids [6, 17].

7.2.5 Prioritize whole foods

Choose whole, unprocessed foods over refined carbohydrates and sugary beverages, as these can contribute to increased liver fat [6, 38].

8. Beverage selection guidelines for NAFLD patients

The body is mostly composed of water, so staying hydrated is crucial for good health. When selecting beverages for patients with NAFLD, it is important to consider the impact of different types of drinks on liver health. Here are some key points based on recent research:

8.1 Avoid sugar-sweetened beverages (SSBs)

Sugar-sweetened beverages are strongly associated with an increased risk of NAFLD. Studies indicate that each additional serving of SSBs per day can significantly raise the prevalence of NAFLD [39–41].

8.2 Limit artificially sweetened beverages (ASBs)

Multiple studies suggest that limiting the consumption of ASBs is advisable in the context of NAFLD [41]. Additionally, Interestingly, replacing SSBs with ASBs has been associated with a higher prevalence of NAFLD, emphasizing the potential adverse effects of ASBs on liver health [40, 42]. Although further research is recommended in this area, the existing evidence highlights the importance of being mindful of ASB consumption for individuals at risk of or managing NAFLD [41].

8.3 Consider low/No-calorie beverages

These may have a nonlinear association with NAFLD, with moderate consumption potentially being safer, but caution is advised as higher intake levels might not be beneficial [40].

8.4 Include coffee and tea

The consumption of coffee and tea has been extensively studied in relation to NAFLD. Although the results of studies have shown conflicting effects regarding the efficacy of these beverages in reducing the incidence and progression of NAFLD [43, 44], there is overall increasing evidence supporting the protective role of coffee and tea in patients with NAFLD [39, 43, 45].

8.5 Moderate fruit juice intake

The consumption of fruit juice in individuals with NAFLD has been a topic of interest in various studies. Research indicates that a higher intake of sugar–sweetened fruit juices is associated with increased NAFLD prevalence. Conversely, low/no-calorie beverages (LNCB) exhibit a nonlinear relationship with NAFLD, suggesting that higher consumption levels may be linked to an increased risk of developing NAFLD [40, 46]. Additionally, studies have shown that 100% fruit juices do not significantly differ from whole fruits in terms of nutrient content; however, whole fruits, due to their fiber content, can help reduce the risk of overweight, obesity, and metabolic syndrome, which are risk factors for NAFLD [47].

9. Dietary approaches for managing NAFLD

In the field of nutritional interventions for individuals with NAFLD, no specific diet has been introduced exclusively for this condition. However, based on existing studies and the effects of the quantity and quality of macronutrients and micronutrients on liver health, two diets that closely align with the nutritional criteria for managing NAFLD are the Dietary Approaches to Stop Hypertension (DASH) diet and, particularly, the Mediterranean diet. Below, we will further introduce these dietary approaches.

9.1 DASH diet

The DASH (Dietary Approaches to Stop Hypertension) diet, originally developed for blood pressure management, offers benefits for liver health. Rich in vegetables, fruits, and whole grains, it promotes low-fat dairy consumption while limiting saturated and trans fats. This approach aids weight loss, reduces inflammation, and decreases oxidative stress – crucial factors in managing NAFLD [48–49]. The diet's low sodium and saturated fat content improve overall metabolic health. Studies show that adhering to the DASH diet is associated with lower NAFLD prevalence, reduced liver fat, and improved liver function markers, including liver enzymes and insulin resistance [48, 50, 51].

9.2 Mediterranean diet

The Mediterranean diet has gained recognition as an effective nutritional strategy for managing NAFLD. This dietary pattern, rich in plant-based foods, healthy fats, and lean proteins, offers multiple benefits for liver health. Key components of the diet include abundant vegetables, fruits, whole grains, legumes, nuts, and seeds, with olive oil as the primary fat source. Fish and poultry are consumed moderately, while red meat and sweets are limited. Research demonstrates several positive effects of this diet on NAFLD:

- Reduced liver inflammation: High antioxidant and polyphenol content combat oxidative stress [52, 53].
- Improved insulin sensitivity: Balanced nutrients help regulate blood sugar levels [54, 55].
- Decreased liver fat: Studies show significant reductions in liver fat content [54, 55].
- Enhanced lipid profile: Lowers harmful cholesterol and triglycerides [56].
- Improved gut microbiome: High fiber intake promotes digestive health, indirectly benefiting the liver [57].

Implementing the Mediterranean diet involves increasing consumption of plant-based foods, using olive oil for cooking, incorporating fish regularly, and limiting red meat intake. However, this dietary approach should be part of a comprehensive NAFLD management plan, including regular exercise and weight control.

Table 1 provides a concise comparison of the DASH diet and Mediterranean diet in the context NAFLD.

Aspect	Mediterranean diet	DASH diet
Main features	• High intake of fruits, vegetables, whole grains • Olive oil as primary fat source • Moderate consumption of fish, poultry, and low-fat dairy • Limited red meat and sweets • Moderate red wine consumption	• Emphasis on vegetables, fruits, whole grains • Lean proteins like fish and poultry • Limited salt, sugar, and saturated fats • Increased intake of potassium, magnesium, and calcium • Controlled portion sizes
Effect on NAFLD	• Reduces liver inflammation • Improves insulin sensitivity • Decreases liver fat • Improves liver enzymes	• Lowers blood pressure, benefiting liver function • Improves blood lipid profile • Aids in weight loss • Reduces insulin resistance
Dietary composition	• 40–50% carbohydrates • 35–40% fat (primarily from olive oil) • 15–20% protein • High fiber (>25 g/day)	• 55% carbohydrates • 27% fat • 18% protein • Low sodium (<2300 mg/day) • High fiber (>30 g/day)
Anti-inflammatory effect	• Highly effective due to high antioxidant content • Reduces inflammatory markers like CRP and IL-6	• Effective, but possibly less than Mediterranean diet • Reduces inflammatory markers, especially in hypertensive individuals
Weight control	• Supports sustainable weight loss • Improves body composition	• May be slightly more effective due to calorie control focus • Faster short-term weight loss

Aspect	Mediterranean diet	DASH diet
Insulin resistance	• Significant improvement in insulin sensitivity • Reduces risk of type 2 diabetes	• Improves insulin sensitivity • Reduces risk of type 2 diabetes
Flexibility	• Generally, more flexible • Easier to adapt to various lifestyles	• More structured approach • Requires more precise meal planning
Overall impact on NAFLD	• Highly effective • Significant improvement in liver fibrosis and steatosis	• Highly effective • Significant improvement in metabolic and hepatic parameters

Table 1.
Comparison of Mediterranean and DASH diets in managing NAFLD.

9.3 Self-assessment tools for adherence to the DASH diet

Self-assessment tools play a crucial role in monitoring adherence to the Dietary Approaches to Stop Hypertension (DASH) diet. These tools help individuals track their dietary intake and assess how closely they are following the DASH diet recommendations. Several validated instruments have been developed for this purpose:

9.3.1 DASH online questionnaire (OLQ)

The Dietary Approaches to Stop Hypertension Online Questionnaire (DASH OLQ) is a web-based dietary assessment tool designed to evaluate the intake of food servings in alignment with the DASH diet. This tool encompasses 11 food groups corresponding to the DASH diet categories and is administered once weekly over a four-week period. The DASH OLQ has been rigorously validated against the Block Food Frequency Questionnaire (FFQ), demonstrating strong correlations in measuring nutrient intake and DASH food group consumption. It provides a quick and efficient method for assessing adherence to the DASH diet, making it a valuable resource for both clinical and research applications [58].

9.3.2 Dash-q

The DASH-Q is a brief self-report tool aimed at evaluating the quality of diet and adherence to the DASH diet. It includes 11 questions focused on the intake of various food groups. This instrument is part of the Hypertension Self-Care Activity Level Effects (H-SCALE) framework. The DASH-Q has undergone validation to confirm its psychometric properties, ensuring it is both reliable and effective for research purposes. It provides a straightforward scoring system that reflects an individual's adherence to the recommendations of the DASH diet. This accessible measure enables researchers and healthcare professionals to effectively assess compliance with DASH dietary guidelines, which are essential for managing hypertension and enhancing cardiovascular health [59].

9.3.3 Mobile apps

Smartphone applications are emerging as innovative tools for DASH diet self-management. These apps, such as NOOM and DASH To TEN, offer a range of features

designed to support dietary adherence. Key functionalities include food logging, goal setting, and access to educational resources. By incorporating behavior change techniques, these apps aim to enhance user engagement and promote long-term dietary modifications. Some applications go further by providing calculations for food servings based on DASH recommendations, offering users precise guidance tailored to their individual needs. As digital health solutions continue to evolve, these mobile apps represent a promising avenue for improving accessibility and effectiveness of DASH diet implementation in daily life [60].

9.4 Self-assessment tools for adherence to the Mediterranean diet

Several self-assessment tools have been developed to measure adherence to the Mediterranean diet. These tools vary in their complexity, components, and scoring systems. Here are some of the most prominent and widely used tools:

9.4.1 14-item Mediterranean diet adherence screener (MEDAS)

This tool, developed in Spain, consists of 14 questions about food consumption and dietary habits. It has been widely validated and used in various countries. The MEDAS can be self-administered or completed by a dietitian, providing immediate feedback on adherence levels [61, 62].

9.4.2 Mediterranean eating pattern for Americans (MEPA)

Developed for use in the USA, MEPA includes food groups typical of the Mediterranean diet but adapted for American dietary patterns. The MEPA-III version has additional components and more detailed food categories. It can be delivered electronically or via phone and has shown good concordance with food frequency questionnaires [4].

9.4.3 Mediterranean lifestyle (MEDLIFE) index

This is the only assessment tool that incorporates dietary behaviors and lifestyle factors along with food intake questions. It aims to capture a more comprehensive picture of the Mediterranean lifestyle [63, 64].

9.4.4 Mediterranean diet score (MDS) by Trichopoulou

One of the earliest and most widely used scoring systems, it's based on population-specific median cut-offs. However, it may have limitations for cross-study comparisons due to these population-specific cut-offs [64].

9.4.5 15-items pyramid based Mediterranean diet score (PyrMDS)

This tool is based on the recommendations of the Mediterranean diet pyramid and is suggested as one of the measurement options [64].

10. Behavioral change guide for improving nutrition in patients with NAFLD

10.1 Setting specific and realistic goals

10.1.1 Short-term, achievable objectives

Establish specific goals, such as losing 0.5 kg per week or engaging in 30 minutes of physical activity daily. These goals should be measurable and realistic to maintain patient motivation.

10.1.2 Long-term goals

Focus on improving liver health and reducing cardiovascular risks through sustainable lifestyle and dietary changes.

10.2 Identifying and managing barriers

10.2.1 Recognizing personal obstacles

Identify barriers such as stress, time constraints, or financial issues that may impede healthy eating and physical activity. Develop strategies to manage these obstacles effectively.

10.2.2 Finding alternative solutions

If time is limited, opt for shorter, more frequent exercise sessions instead of lengthy workouts. To combat stress, explore relaxation techniques like meditation or yoga.

10.3 Leveraging social support

10.3.1 Family and friend support

Engage family members and friends for encouragement and companionship in lifestyle changes.

10.3.2 Participation in support groups

Joining exercise groups or weight loss programs can help maintain motivation and facilitate experience sharing.

10.4 Continuous monitoring and evaluation

10.4.1 Food journaling

Recording daily food intake and physical activities helps individuals better understand their dietary and activity patterns, enabling necessary adjustments.

10.4.2 Regular progress assessment

Utilize self-assessment nutrition tools introduced in the previous section and physical activity self-assessment applications to measure progress in behavior change. This practice helps individuals recognize their achievements and find greater motivation to continue.

10.5 Making healthy nutritional choices

10.5.1 Embracing liver-friendly dietary patterns

Adopt Mediterranean, DASH, or other dietary patterns rich in fruits, vegetables, whole grains, lean proteins, and healthy fats, as explained in the previous section, to improve liver health.

10.5.2 Portion control

Implement portion control techniques such as using smaller plates and accurately measuring food quantities to reduce calorie intake.

10.5.3 Limiting processed foods

Reduce consumption of processed meats, refined carbohydrates, and sweetened beverages to prevent liver condition deterioration.

10.6 Enhancing motivation and persistence

10.6.1 Self-rewarding

After achieving short-term goals, reward oneself. This reward can be an enjoyable activity or a desired purchase.

10.6.2 Embracing small changes

Significant and lasting changes require time. Instead of focusing on sudden changes, gradually improve eating and exercise habits to achieve long-term success.

10.7 Utilizing professional resources

10.7.1 Consultation with a nutritionist

Seeking advice from a nutrition specialist to develop a personalized meal plan tailored to individual needs can be beneficial.

10.7.2 Healthcare team support

Maintain contact with physicians or gastroenterologists to monitor health status and implement necessary medication or further dietary changes as needed.

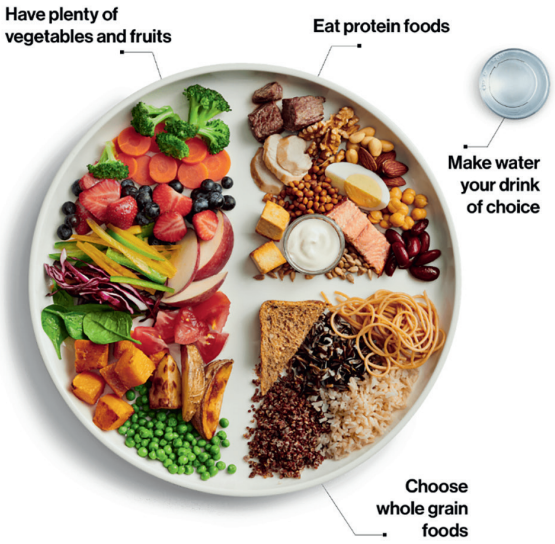

Figure 2.
A healthy plate for managing nonalcoholic fatty liver disease. Source: © All rights reserved. Canada's Food Guide: Snapshot. Health Canada, 2019. Reproduced with permission from the Minister of Health, 2024 [65].

11. Conclusions

Nonalcoholic fatty liver disease is a complex metabolic disorder closely linked to lifestyle factors. Effective management primarily revolves around dietary modifications, increased physical activity, and weight reduction. While overall calorie restriction is crucial, the composition of the diet significantly influences NAFLD outcomes.

This chapter delved into the intricate relationship between macronutrients and NAFLD, emphasizing the importance of carbohydrate quality, fiber intake, and the need to minimize added sugars. The role of fruits and vegetables in providing essential nutrients and antioxidants was highlighted, along with the significance of protein intake for maintaining muscle mass and supporting liver health. The importance of selecting low-fat dairy products and understanding the impact of different fat types on liver health was also discussed. **Figure 2** summarizes the ideal daily intake of food groups that can support liver health, as well as the key nutritional concepts discussed in this chapter.

Two dietary approaches, the DASH diet and the Mediterranean diet, emerged as promising strategies for managing NAFLD. Both emphasize whole foods, reduced intake of processed products, and a balanced macronutrient profile. Self-assessment tools were introduced to facilitate adherence to these dietary patterns.

Behavioral change is essential for long-term success in managing NAFLD. Setting realistic goals, identifying and overcoming barriers, and leveraging social support are crucial components of this process.

In conclusion, a comprehensive approach combining dietary modifications, physical activity, and behavioral changes is essential for managing NAFLD. By understanding the role of macronutrients, incorporating diverse food groups, and adopting suitable dietary patterns, individuals can improve liver health and overall well-being.

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Conflict of interest

The authors declare no conflict of interest.

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