ROLE OF NUTRITION IN NON-ALCOHOLIC FATTY LIVER DISEASE (NAFLD)

Abstract

The rampancy of non-alcoholic fatty liver disease (NAFLD) has intensified in recent years, making it a significant health issue. It comprises simple steatosis, nonalcoholic steatohepatitis (NASH), fibrosis, cirrhosis, and hepatocellular carcinoma (HCC), among other hepatic injuries. Numerous aspects, such as environmental (dietary practices and routine exercise) and acquired (genetic/epigenetic) hazards, influence the susceptibility to NAFLD. In NAFLD, the most important therapeutic objective is weight loss through a hypocaloric diet. No drug choices are right now endorsed for the cure of NAFLD. Dietary changes and exercise remain the mainstays of NAFLD treatment. The significance of following a Mediterranean diet, low-carb diet, intermittent fasting, and DASH diet appears to have beneficial effects. The liver is negatively impacted by macronutrients such as meat proteins, trans fats, simple carbohydrates, and saturated fats (SFA). On the other hand, the liver is thought to benefit from Omega-3 fats, proteins derived from plants, dietary fibers, monounsaturated fats (MUFAs), polyunsaturated fats (PUFAs), and PUFAs. This review provides a complete rundown of dietary principles to combat the rising burden of NAFLD, focusing on and understanding how diet affects metabolism and the liver and also discusses the role and significance of nutrition and diet interventions in treatment of NAFLD.

Keywords: NAFLD; weight loss; Mediterranean diet; lifestyle intervention; probiotics.

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I. INTRODUCTION

Fat buildup in the liver of persons who either use hardly any alcohol is known as non-alcoholic fatty liver disease (NAFLD). NAFLD is the most frequent, affecting around 9% to 32% of Indian people in general and approx. 25% of the global aged population (Younossi *et al*., 2019). The most serious and widespread illness in the US is NAFLD. It is, among the many widespread forms of chronic liver condition worldwide, and is currently responsible for a sizable amount of liver-related morbidity and death. The large mass formation of fat in the liver, which starts with the buildup of lipids in the liver, is one of the dangers that develop in NAFLD. (Byrne and Targher, 2015). NAFLD can occur in people of normal weight as well, especially in Asian populations, despite the strong link to obesity. Cirrhosis deaths climbed from 899,000 to 1.32 million globally between 1990 and 2017, while the number of years spent with a disability rose from 30.5 million to 41.4 million. The frequency of cirrhosis cases with compensation caused by NASH tripled during this time, while the number of decompensated cirrhosis more than tripled. As a consequence of improved preventive and treatment strategies, it is projected that NASH will soon overtake hepatitis B and C as the primary cause of cirrhosis. (Lazarus *et al* ., 2021). According to recent research, women are experiencing a higher mortality rate and a greater increase in NAFLD cases than men. The maladjusted cases of NAFLD increased from 21.36 percent between 1999 and 2006 and 24.86 percent between 2007 and 2014 (DiStephano, 2020). Typically, NAFLD has no visible symptoms or indicators. Tests on the liver are the only approach to identify NAFLD. In rare situations, nonalcoholic steatohepatitis (NASH), a more severe liver condition, develops from NAFLD (Hydes *et al*., 2020). Inflammation and fat accumulation brought on by NASH may result in fibrosis or scarring in the liver. The illness NASH worsens over time. Cirrhosis or liver failure can result from NASH after fibrosis has formed.

Obesity, diabetes, hypertension, and metabolic syndrome are all linked to non-alcoholic fatty liver disease. Nearly 25% of NAFLD patients have non-alcoholic steatohepatitis (NASH), with a 20% potential of progressing to cirrhosis. According to data, NAFLD is anticipated to impact up to 91% of people with a body mass index (BMI) of >30 kg/m2 and 67% of those with a BMI of 25 to 30 kg/m2. According to estimates, 40–70% of people with diabetes type 2 mellitus (T2DM) suffer from this ailment (Hydes et al., 2020). According to Lazarus et al. (2021), for those with NAFLD, heart condition is the leading cause of fatalities. Non-Alcoholic Fatty Liver Disease progresses through four stages (NAFLD).

- Simple steatosis or fatty liver
- Non-alcoholic steatohepatitis (NASH)
- Fibrosis
- Cirrhosis

Steatosis, or straightforward fatty liver, is the initial stage. The liver cells begin to deposit fat, but there is no inflammation or injury at this point. There are typically no symptoms of hyperlipidemia, so the majority of people are unaware that they have it at this early stage. With proper nutrition and consistent exercise, excess fat in liver cells can be eliminated, and for most people, the fatty liver does not progress further. It is estimated that 20% of people with essential fatty livers will eventually develop non-alcoholic steatohepatitis, or NASH.

Fat accumulation in hepatocytes, along with inflammation and irritation, is the cause of nonalcoholic steatohepatitis (NASH), the secondary stage of NAFLD. So when the liver is recuperating harmed tissue, irritation happens. The inflammatory tissue may eventually scar as a result of the liver's inability to adequately repair the damaged tissue. Scar tissue formation is known as fibrosis.

The tertiary stage of NAFLD, fibrosis, is caused by recurrent scar tissue in the blood vessels around the liver and in the liver itself. At this point, the liver is still able to carry out its functions fairly correctly, and eliminating or treating the inflammation may stop it from spreading or perhaps repair some of the damage. The liver's efficiency is impacted if, over time, a significant portion of the normal liver tissue begins to be replaced by scar tissue. Cirrhosis may result from this.

Cirrhosis is the fourth NAFLD stage. At this point in time, the liver ceases to function effectively, leading to symptoms including discoloration of the epidermis and sclera as well as a dull discomfort on the lower right side of the ribs start to develop. Although it is complicated to eliminate the scar tissue in liver cirrhosis, further growth can be stopped if the cause of the liver damage is remedied (Kudaravalli and John, 2022).

In the majority of patients with mild steatosis, about 20% and 30% develop NASH with advanced fibrosis. Of that 20% who build up cirrhosis, are more likely to develop the risk of hepatocellular carcinoma. Genetic changes, getting older, inflammation, dysbiosis in the gut, and metabolic abnormalities like insulin resistance and hyperinsulinemia are all NAFLD worsening hazards (Kasper *et al*., 2020).

There are no pharmacological medicines for NAFLD supported by the US Food and Medication Organization and since the exploration about the treatment of NAFLD patients doesn't exist, way of life change zeroed in improved and good dieting habits, standard physical activity, and weight reduction stays areas of strength for the administration of patients enduring with NAFLD. Indeed, significant improvements in glycemic management, hepatic sensitivity to insulin, liver enzymes, and hepatic diagnoses (Meroni et al., 2020). Dietary balance, especially a diet high in simple carbohydrates, may help improve NAFLD, while indigestible carbohydrates like fiber help keep the gut wall and microbial community healthy. While intake of unsaturated fat has some beneficial effects, consumption of saturated fat may also support the development of NAFLD. Protein admission doesn't appear to modify the advancement of NAFLD (Bonsembiante *et al*., 2021). Unbalanced nutrition has a significant impact on NAFLD and is also a danger aspect affecting a huge population. As a consequence of this, it is absolutely necessary to identify dietary guidelines that can be altered to lessen the likelihood of developing NAFLD and its complications. For all NAFLD patients, regardless they are obese or of a healthy weight, a well-rounded diet provides advantages beyond weight reduction. Omega-3 fatty acids should be their main emphasis, and they should consume more polyunsaturated fat and less saturated and trans fat. Eating a nutritious diet may be made simpler by avoiding fast food. Because even modest improvements in PA & fitness may have a significant result on one's health, PA therapy should be incorporated into behavioral therapy for NAFLD. Vitamin E and vitamin D supplements could be helpful, although further study is required on each (Sagi *et al*., 2011).

II. LIFESTYLE MODIFICATIONS AND PHYSICAL ACTIVITY

Because there is no approved medication or surgical procedure, the most important aspects of managing NASH are still diet, exercise, and physical activity. Weight control and disorders of the metabolism are the primary objectives of these strategies (Raza *et al*., 2021). The most pliable cure for NAFLD/NASH is lifestyle modification, which may include changing one's diet and getting more exercise. Insulin resistance, T2DM25, and NAFLD are all linked to decrease levels of moderately intense activity & high lack of movement (Cardoso *et al*., 2021). Any kind of activity that involves a lot of muscle fibers and can be sustained consistently for a while is considered an aerobic workout. It is also known as "cardio" or "cardiovascular exercise." Oxygen-consuming activity over-burdens heart and lungs, making them to put a lot of effort and whenever done consistently, works on cardiorespiratory wellness. Regular aerobic exercise has several advantages, one of which is a decreased risk of cardiovascular disease (CVD). This is integral to keep in mind regarding the NAFLD/NASH patient population because only 9% of fatalities are from liver-related causes and 38% from CVD. (Hallsworth and Adams, 2019). Exercise is known to help reduce liver fat, and sedentary practices are a strong autonomous indicator of NAFLD (Wong *et al*., 2022). For the foremost purpose of avoiding metabolic illnesses and lowering the chance of developing them, general health guidelines suggest 10,000 steps per day or 150 minutes of moderately vigorous leisure time physical activity per week. However, this target is not met by the majority of the general population which could be responsible for the rise in obesity, T2DM, and NAFLD cases. (Hallsworth and Adams, 2019).

A large percentage of those suffering from NAFLD do not follow exercise recommendations, despite the fact that physical activity enhance metabolic control and is suggested for them (Michel and Schattenberg, 2020). After three months, the controlled reduction parameter, a measure of hepatic steatosis, showed the greatest reduction when a low-glycemic-index-MED was used in simultaneity both aerobic activity and strength training, or both (Semmler *et al*., 2021). A higher risk of developing NAFLD may result from an increase in sedentary time. Interestingly, it is believed that taking fewer breaks from sitting can help control obesity and improve glucose and fatty acid metabolism (Raza *et al*., 2021). According to the findings, all patients with liver disease experience significant difficulties in eight domains of physical function: getting dressed, ingesting, moving around, and maintaining personal hygiene, reaching, gripping, and activity are all covered. Aging, fatigue, autonomic dysfunction, and cognitive impairment, are all associated with NAFLD patients (Macavei *et al*., 2016). Improvement in NAFLD is linked to diet and exercise-induced weight loss. However, there are a number of obstacles in the way of achieving these results:

- To improve patient outcomes, NAFLD patients must be identified early.
- Comprehension of the intricate pathophysiology that underlies the onset, progression, and interaction of NAFLD with other metabolic organs is required.
- Albeit guideline of taking care of and actual activity offer methodologies to treat NAFLD, yet keeping a weight reduction in testing (Carneros et al., 2020).

III. DIETARY INTERVENTIONS

Dietary habits are quite effective in preventing the emergence of NASH even in spite of weight reduction. The role of nutrition and dietary recommendations for treatment of NAFLD is the subject of this article. Persons with NAFLD may select from a variety of other eating regimens, including the DASH diet and the keto lifestyle. Eating regimen like intermittent fasting may be a secure and successful therapy for metabolic syndrome in healthy individuals, according to recent research in clinical studies. The Mediterranean diet, low-carb diet, low-fat diet, and Dietary Approaches to Stop Hypertension (DASH) diet are the four which are most frequently used eating plans.

Types of Diet in Non-Alcoholic Fatty Liver Disease

Diet	Description
Low-carbohydrate diet/ Ketogenic diet	• Helps in major weight reduction, improve the blood lipid profile and insulin resistance. • Less than 10% of the daily caloric intake come from carbohydrates (20–50 g per day). • Long-term attention can bring about micronutrient insufficiency or inadequacy in the event that the eating regimen isn't suitably directed.
Mediterranean diet	• Low in triglycerides and fatty substances; favors the liver; linked with a decreased incidence of fibrosis, NAFLD, and NASH. • Rich in polyunsaturated omega-3 fatty acids and MUFA, with an ideal ratio of omega-6 to omega-3 fats • Rich in dietary fiber, plant-based proteins, and complex carbs.
Intermittent fasting	• Help lose weight, reduce inflammation in the gut and throughout the body, improve dysbiosis and microbial diversity in the gut. • Alternate-day fasting- eating normally for 24 hours and not eating at all for the next 24 hours. • The 5:2 fast- cutting calories for two days (500 calories per day) and then eating normally for five days. • Time-restricted fasting, or TRF, is when you only eat from 12 p.m. to 8 p.m. each day
DASH diet	• High in chicken, fish, veggies, fruits, low-fat dairy products, & nuts. • Minimal in processed and red meats, drinks that are sugary, and sugar-added beverages. • Contributes- reductions in oxidative stress, inflammation, fasting glucose levels, and total cholesterol, all of which are cardiovascular risk factors.

1. **Mediterranean Diet:** A number of clinical studies have examined the therapeutic outcomes of the considered Mediterranean-style diet (MD) and its adaptation to a Mediterranean lifestyle. The diet represents the 1960s eating customs of Greece, Italy, and Spain, which are "traditional" (albeit now hardly followed) (Pouwels *et al*., 2022). European guidelines have suggested using the Mediterranean diet for the cure of NAFLD. This dietary regimen follows the principles of nutritional treatment for NAFLD and benefits the liver and other body parts beyond weight loss (Wong *et al*., 2022). The Mediterranean diet may be categorized as a diet centered on plants with high percentage of MUFA to (SFA) and consuming 30%–40% of one's daily calories from total fat. It is subsequently a high-fat eating regimen, with fat involving 35%-45% of the total energy consumption, a big part of which ought to be from MUFAs. Protein accounts for 15%–20% of energy intake, while carbohydrates account for 35%–40%. As a result, the MD contains a lot of macronutrients that have been shown to help prevent fatty liver disease and improve glucosidic and lipidic metabolism. (Torres *et al*., 2019). MD is a healthy diet that has been demonstrated to reduce the possibility of diabetes type 2, metabolic syndrome, and CVD. It contains a good balance of omega-3 to omega-6 fatty acids, is restricted in saturated fatty acids and animal protein, packed with antioxidants, fiber, and monounsaturated lipids (MUFA). (Anania *et al*., 2018). Plant foods (fruits, vegetables, bread, and other cereals that are typically minimally refined), potatoes, beans, nuts, and seeds make up a large portion of the traditional Mediterranean diet. Foods that are locally grown, seasonal, and minimally processed; traditional desserts include fresh fruit as well as occasional treats prepared with honey & sugar; a substantial amount of virgin and extra-virgin olive oil intake as the only source of fat; Few dairy items, primarily cheese, and curd; low to sufficient levels of fish and poultry intake; minimal red meat consumption (Ferré and Willett, 2021). The macro- and micronutrient content of the Mediterranean diet has been demonstrated to enhance health and minimise the risk of heart disease. Additionally, this diet is distinguished by its use of nuts. In spite of the rich content of mono- and polyunsaturated FA's, which aid in lowering insulin resistance and serum cholesterol, as well as dietary fiber, which has a lowering effect on lipids, these foods may be beneficial for health; moreover, nuts contain cancer prevention agents, which might diminish oxidative pressure and irritation. In recent years, health authorities issued warnings regarding the consumption of nuts because these foods may pose a high risk of contamination with aflatoxin (AF), for which different countries have different regulations and laws. Hepatocellular carcinoma is a known risk factor for aflatoxin, a well-known poisonous cancer-causing agent. Patients with NAFLD have higher chances of creating hepatocellular carcinoma in comparison with population as a whole. In this situation, one could claim that the advice to NAFLD patients to incorporate nuts in their diets has to be balanced against the risk of probable chronic AF exposures. (Angelico *et al*., 2021).

Vitamins, polyphenols, and other compounds with inflammatory- and antioxidant-fighting capacities are the foundation of MD. Given the substantial roles that inflammation and oxidative damage play in the etiology of NAFLD/NASH, this seems like a reasonable choice. Polyphenols are often found in whole grains, cereals, fresh fruit, vegetables, olive oils, and almonds. They are a diverse collection of substances with bioactive properties with a phenolic structure, some of which are hydro-soluble antioxidants. Vitamins, which make up a lot of MD, can also be considered antioxidants in the diet. They are essential in stopping the development of NAFLD because they lessen

cellular stress. Vitamin E improves the histologic traits associated with NASH (Anania *et al*., 2018). The Mediterranean diet has been recognized as the ideal diet because it is straightforward to follow and because its dietary content have advantageous effects on metabolism that reduce steatosis and cardiovascular event hazards, which are the primary cause of fatality and death in persons having NAFLD, regardless of calorie intake (Pugliese *et al*., 2022).

2. **Dash Diet:** The DASH (Dietary Approaches to Stop Hypertension) diet, which originally emerged with the motive of controlling hypertension, focuses on reducing foods high in energy density and lipids, overall fat, and saturated fat. It is high in fruits, veggies, limited-fat dairy items, whole grains, poultry, fish, and nuts but low in drinks with sugar in them, red meat, and processed animal products and added sugars. It has protein and fiber, calcium, potassium, magnesium, and other minerals (Riazi *et al*., 2019). It is believed that the DASH diet represents a substantial advancement in nutritional studies. It restricts foods high in sugar and saturated fat. Although DASH is not a low-sodium diet, reducing sodium intake enhances its effectiveness (Steinberg *et al*., 2017). The DASH diet plan encourages a high consumption of protective nutrients like potassium, calcium, magnesium, fiber, and vegetable proteins while simultaneously reducing the consumption of refined carbohydrates and saturated fat. It is essential to remember that the DASH diet has a positive impact on more than blood pressure. Inflammation, oxidative stress, and well-known cardiovascular risk variables including fasting glucose levels and total cholesterol have all shown notable improvements in several trials. (Siervo *et al*., 2015). The DASH diet is a promising strategy to help decrease the risk of cardiovascular disease, diabetes, and a metabolic disorder in addition to its benefits for decreasing blood pressure. In a meta-analysis, Shirani *et al*. described how the DASH diet scores score was linked to an improvement in insulin sensitivity. Other studies suggested that following the DASH diet might lead to a decrease in inflammatory markers (Doustmohammadian *et al*., 2022). Mahdavi *et al*., studied that adolescent men with hemophilia who followed the DASH diet had less liver steatosis and fibrosis after 10 weeks. Observational and interventional studies have found a connection between the phytochemicals and other substances of the DASH diet and the modification of inflammatory biomarkers, permeability of the gut and likelihood of infection in the body. (Rooholahzadegan *et al*., 2023). According to the clinical trial held by Rooholahzadegan *et al*, people with NAFLD have been depicted to comply with the DASH diet for eight weeks might noticeably improve their liver function as a result of lower BMI, meta-inflammation and the response to glucose.

3. **The Low Carbohydrate Diet (LCD) / Ketogenic Diet (KD):** The terms "ketogenic" or "low carbohydrate diets" refer to eating extremely little or no carbohydrates at all. The ketogenic diet (KD) confines the intake of carbs to between 20 and 50 grams per day, or less than 10% of the total daily calories consumed, even if the precise composition of macronutrients may vary. The KD is an effective strategy for encouraging weight reduction and attaining more sustained weight reduction as compared to diets with low fat. (Lujan *et al*., 2021). Very low carbohydrate diets (VLCD) are deemed to be ketogenic by the European Food Safety Authority (EFSA) if they include a predetermined value of fat (20 g/day), the protein content of 1.2-1.4 g/kg of optimal body mass (roughly 75 g/day), and very little carb (30-50 g/day, 5-10%). In his "Letter on Corpulence Addressed to the Public," the obese former English undertaker and coffin manufacturer William

Banting presented a weight-controlling diet that excluded bread, butter, milk, sugar, alcohol, and potatoes. LCDs have been shown to be useful in the treatment of obesity in recent years, and in addition to significant weight loss, they have a significant impact on insulin sensitivity and plasma lipid profiles. (Watanabe *et al*., 2020). KDs are the spotlight for NAFLD, obesity, and neurological diseases. Despite the fact that they have beneficial properties, the metabolic effects of these diets are still poorly understood, and patient responses can vary. The impact of shifting macronutrient class distributions and macronutrient content's role in liver health have been the subject of recent research. Thus, additional factors such as the effects of inadequate total protein, choline, and methionine intake, as well as the saturation and duration of dietary fatty acids, must be considered in future research on low-carbohydrate diets in humans. It will be crucial to achieve a balance of macro- and micronutrients in order to develop diets that successfully promote weight loss while preserving systemic health (Schugar *et al*., 2012). Adipose tissue-derived free fatty acids account for 60–80% of the hepatic triglycerides in healthy individuals, followed by dietary free fatty acids (15%) and lipogenesis (5%). On the other hand, due to insulin resistance, the level of hepatic triglycerides produced from the start of lipogenesis is five times greater (26%) in patients with NAFLD than in healthy individuals (5%). This physiological perspective may provide an explanation for the promising role that exposure to a keto diet plays in the management of NAFLD, given that the majority of anew lipogenesis is caused by the metabolism of circulating glucose. A ketogenic diet plan of eating fewer carbs requires an outrageous aversion to starch food sources to produce healthful ketosis. Since carbohydrates are a good source of nutrients such as vitamins and minerals and bioactive chemicals like polyphenols, sustained consumption of a ketogenic diet may result in a shortage of micronutrients or inadequacy if the diet isn't well planned. (Sripongpun *et al*., 2022).

4. **Intermittent Fasting (IF):** A type of eating that restricts food intake for a fixed duration to enable the body to go into a phase of fasting is known as intermittent fasting (IF). Alternate-day fasting involves eating normally for 24 hours and not eating at all for the next 24 hours. The 5:2 fast involves drastically cutting calories for two days (500 calories per day) and then eating normally for five days. In contrast, periodic fasting entails intermittent fasting that lasts longer than two days and involves eating fewer than 500 calories per day. Time-restricted fasting, or TRF, is when you only eat from 12 p.m. to 8 p.m. each day (Memel *et al*., 2022). It is a non-pharmacologic nutritional way to deal with metabolic conditions, including intermittent time frames or close total withdrawal from food and beverages that contain energy. This diet strategy has recently become quite well-liked in popular culture. It has been demonstrated to support weight loss, lessen gastrointestinal and systemic inflammation, and enhance dysbiosis and microbial diversity in the gut. It has been speculated that intermittent fasting may help cure NAFLD because of the link to obesity. (Lavallee *et al*., 2022). According to Holmer *et al*.'s investigation, the 5:2 diet was more palatable, lowered liver stiffness, and had a greater impact on the levels of LDL cholesterol more than the LCHF diet. As a result, individuals with NAFLD, ultimately for those who have cardiovascular risks, may benefit more overall from the 5:2 diet. According to Memel *et al*.'s research, intermittent fasting is a viable, secure, and efficient weight reduction method for NAFLD patients. Non-invasive testing (NIT) indicates substantial trends towards improvements in dyslipidemia and NAFLD. The lowest hazards were hunger, irritation, and decreased focus.

IV. ROLE OF PROTEINS

Studies and research on the involvement of proteins in the pathophysiology of NAFLD are scarce or constrained. Research studies have demonstrated that protein consumption influences NAFLD development. Hepatic steatosis and NASH are brought on by hunger and a lack of protein. By preventing lipogenesis from the start, diets rich in protein and low in carbs enhance glucose metabolism and hepatic steatosis. Ingestion of protein-rich foods is essential for hepatocyte rejuvenation and supplies the essential amino acids required to stop fat buildup in the liver. Arciero *et al*, recommended a reasonable protein rich diet for NAFLD patients after demonstrating (in 2008) that a diet at moderate levels of protein has the same effect on body fat percentage as a high protein diet without any side effects (Ullah *et al*., 2019).

V. ROLE OF CARBOHYDRATE

In addition to being macronutrients, sugar like sucrose plus high fructose corn syrup (HFCS) accelerates newly formed lipogenesis, increasing the probability of acquiring NAFLD and NASH. Fructose may trigger NAFLD by acting as an increased reagent for DNL and avoiding the crucial limitation procedure of glycolysis at phosphofructokinase. Continuous intake of fructose induces fructokinase and fatty acid synthase, which can lead to metabolic stress in the liver (Basaranoglu *et al*., 2015). Fructose, in particular, triggers starting of lipogenesis that is responsible for 26 percent of the liver's elevated levels of fatty acids. Consumption of fructose in the diet, particularly in sweetened beverages, is higher in NAFLD patients and is linked to increased fibrosis and inflammation. Ketogenic diets with very few carbs have been shown to reduce obesity-related histologic markers such steatosis, inflammation, and fibrosis as well as liver lipid levels. (Rives *et al*., 2020). It has also been investigated how a low-carb diet affects the liver's ability to process free fatty acids and maintain glucose homeostasis. In five NAFLD patients, Tendler *et al*. inspected the effects of a low-sugar diet (20 g/d) on hepatic steatosis. Repeated liver samples after six months showed a 12.8-kilogram weight loss and an overall reduction in inflammation, steatosis, and fibrosis. (Nseir *et al*., 2014).

VI. ROLE OF DIETARY FIBRE AND PROBIOTICS

Preclinical models are useful in understanding the relevance of bacterial overgrowth and intestinal dysbiosis in the course of illness, as several pieces of proof exists that the composition and functioning of the gut flora are critical to the growth and development of obesity and NAFLD. In fact, the host nutrient metabolism may be negatively affected by the unbalanced intestinal flora, promoting obesity and fatty liver. Patients with NAFLD-related dysbiosis frequently have shifts in their metabolic functioning of gut microbiota, which is known as leaky gut, and these changes are somewhat tied to NAFLD severity. Indeed, fibrosis and NASH have been independently linked to an equivalent quantity of Bacteroides and Ruminococcus (Meroni *et al*., 2019). Live, non-pathogenic microorganisms known as probiotics modify GM in sufficient quantities to benefit the host's health. In latest clinical studies, Lactobacilli, Streptococci, and Bifidobacteria have been mentioned frequently. Prebiotics are non-edible carbs that can be aged by microscopic organisms and therefore change GM structure and movement to advance medical advantages. A synbiotic is a supplement that combines prebiotics with probiotics. Patients with NAFLD may benefit from

the capacity of synbiotics and probiotics to restore GM balance and reverse dysbiosis. (Xie *et al*., 2019). Fiber consumption emphatically impacts NAFLD by advancing decreased calorie intake as well as by rejuvenating a sound and healthy stomach microbiota, in this manner decreasing inflammation and liver injury. Fibrosis is a more sophisticated form of NAFLD, and has not been observed to diminish in any research so far in individuals who consume a lot of fiber or take prebiotic supplements. The data shows that its use in the early stages of NAFLD helps to stop its development, while further study is necessary in this area. (Pérez-Montes *et al*., 2020).

VII. ANTIOXIDANTS AND NAFLD

NAFLD progression is linked to a decline in antioxidant status and an increase in lipid peroxidation. Due to the common link that exists between oxidative damage and the onset of NAFLD, several antioxidants have been tested both experimentally and clinically in NAFLD patients. Antioxidants consisting of resveratrol, pentoxifylline, silymarin, silybin, silibinin, and vitamins A, C, and E are currently being explored in clinical trials to treat NAFLD. One of the plant's metabolites called silybin plays a specific role in regulating the digestion of lipids and stress caused by oxidation. Resveratrol, an acknowledged SIRT 1 and AMPK activator, suppresses the SREBP1c needed to restart lipogenesis. Additionally, resveratrol protects the liver from epigenetic disruptions by preventing methylation at the Nrf-2 promotor (Ezhilarasan and Lakshmi, 2022).

One of the body's strongest antioxidants that prevent chains from snapping is vitamin E. Other anti-oxidative enzymes like catalase and glutathione peroxidase are boosted by vitamin E. Major triggers for stress-related oxidative damage include nitric oxide synthase and nicotinamide adenine dinucleotide phosphate oxidase in its reduced form, and can be decreased by dietary vitamin E through the modulation of gene expression. Vitamin C, like vitamin E, is a potent antioxidant that has the potential to lessen the oxidative stress experienced by NAFLD and NASH patients. In a number of studies aimed at treating NASH and NAFLD, vitamin C and vitamin E were used together as anti-oxidative treatments. Additionally, professional use of vitamin D rehabilitation is restricted since it may cause hypercalcemia, which a risk factor for NAFLD., and its effect on calcium homeostasis (Perumpail *et al*., 2018).

VIII. CONCLUSION

Nutrition is a big part of how NAFLD develops. There has been a lot of study during the past ten years on the connection between NAFLD, dietary patterns, nutrients, and foods. Research on the function of nutrients in administration of NAFLD patients is a major problem and is crucial in light of the finding that altering one's lifestyle, like eating better, exercising, and losing weight, can help control NAFLD. The Mediterranean eating regimen brings about critical improvement in steatosis, even without even a trace of weight reduction. Diets high in fat and carbohydrates, two macronutrients, promote or halt the emergence of NAFLD. NAFLD development is due to fructose from carbohydrates and can be prevented by MUFAs and -3 fatty acids from fats, low glycemic carbohydrate diets, and fiber. For people who track down caloric limitations troublesome, replacing their previous diet with healthy alternatives without lessening calorie intake might offer a more easy option, although the advantage to liver wellbeing isn't quite as set apart as weight decrease. Antioxidants like

vitamin D, vitamin E, vitamin C, and polyphenols are among the micronutrients that stop the further development of NAFLD. However, many areas of NAFLD research are still emerging and require additional testing and research, such as the roles that proteins, vitamin C, and vitamin D play in the etiology and curative therapy of NAFLD.

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