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ROLE OF PROTEIN IN SATIETY AND WEIGHT MANAGEMENT

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ABSTRACT

Obesity is the leading modifiable risk factor in the development of non-communicable diseases (NCDs). Globally, 66% of all deaths are caused by NCDs. The prevalence of overweight and obesity has increased rapidly in recent decades in both developed and developing countries. In India about 1 in every 5 kids is overweight. Many pathways are involved with obesity that lead to the development of various NCDs. Foods high in complex carbohydrates like whole grains and fibre, proteins, increase satiety leading to weight loss, decrease postprandial blood glucose rise, improve insulin sensitivity & improve blood lipid profile. Protein has a wide range of functions and benefits in the human body including muscle and immune and endocrine functions. A secondary effect of these functions is manifested as weight management and satiety. Plant proteins and millets are a good solution for satiety and weight management and for NCDs management in the longer run by people. They are sustainable sources of adequate nutrients being good for people and good for the planet. *Leptin* and *ghrelin* are two important hormones playing significant roles in satiety management where, the hypothalamus regulates the sensations of hunger and satiety, leading to energy homeostasis and body weight management**.** Obesity decreases the quality and health length of life. In the context of the worldwide epidemic of obesity affecting populations of all ages, it is important to understand the mechanisms that control the human appetite, particularly those that allow the adjustment of energy intake to the energy needs.

Keywords: Protein, Weight management, NCDs, Satiety, Leptin

INTRODUCTION

Obesity is one of the leading causes of the development of several non-communicable diseases (NCDs) like diabetes, cardiovascular diseases (CVDs), respiratory diseases and cancers. Globally, 66% of all deaths are caused by NCDs and 75% of these deaths are from low- and middle-income countries (LMICs). The prevalence of overweight and obesity has increased rapidly in recent decades in both developed and developing countries. Globally, 39% of adults and 9 million children under the age of 5, were overweight in 2020. In India, the annual increase in adult obesity is very high (5.2%) while that of children is 9.1%. Suboptimal diets that are low in beneficial components like proteins, fibre, whole grains, fruits, nuts and polyphenols coupled with those high in sugars, saturated fat and sodium are the leading etiological factors for NCDs (Sotlani 2016; Dorairaj 2018, GBD 2019; WHO 2023). The recent ICMR - INDIAB (India Diabetes) study reported that about 15% of Indians are prediabetics and 11% diabetic. About 57% are unaware of the condition and devoid of appropriate medication leading to worsening of the condition (Anjana et al 2023).

Many pathways are involved with obesity that lead to the development of various NCDs. These include the mechanical stress of obesity and the complex changes in hormones and metabolism. Mechanisms leading to controlled appetites lead to controlled calorific intakes,

further better managed ideal fat and body mass over a longer time as imperative to help adjust energy intake according to the energy needs.

Complex carbohydrates, proteins, and fibres (especially viscous *soluble fibre* like *beta glucan from oats and barley*) make foods lower in Glycemic index (GI). This may be due to delayed gastric emptying, modulating gastric hormones which increase the satiety leading to weight loss, decrease postprandial blood glucose rise, improve insulin sensitivity & improve blood lipid profile, by reducing low density lipoprotein cholesterol (LDLc) and increasing high density lipoprotein (HDLc) (Choudhary 2004).

Satiety and metabolic impact

While hunger and numerous circumstantial cues stimulate eating, satiety is an important *psycho-biological mechanism* that inhibits repeat intakes of food. The intensity and duration of post-ingestive inhibition are determined by several factors, including the nutrient composition of the foods or drinks consumed. Depending on its nutrient content, a food exerts a certain "*satiating power*". Enhancing the specific satiating efficiency of food might be a way to increase the intensity and duration of the post-meal inhibition of appetite and control the energy intake (Sotlani et al 2016).

Satiation is the phenomenon of ceasing to eat during one eating occasion due to the feeling of fullness. ***Satiety*** refers to the extended feeling of fullness after one eating occasion to the next one. It involves afferent signaling induced through physiological processes, including satiety-signaling pathways from the gastrointestinal tract to the CNS (Akhavan et al 2009). This sense of satisfaction enables one to hold on for some time without feeling to eat again or crave for food. Eating episodes are not only triggered by hunger and nutritional requirements by also by other determinants like get together and psychological or stressed conditions. During such episodes, frequent feeling of satiety is important to restrict overeating leading to overconsumption of calories and in turn obesity (Joseph 2020). Usually, foods rich in fats, fibre and protein lead to longer satiety duration. Contrarily, foods high in simple carbohydrates get absorbed and assimilated faster leading to faster generation of glucose. This glucose, when not used for oxidation in the cells is stored as glycogen in the liver and prolonged high levels are converted into fat cells in the adipose tissues.

Hormones and Satiety

Complex interactions between hormones from the gastro-intestinal tract (GIT) and the central nervous system (CNS) and subsequent feedback systems play a pivotal role in generating feelings of appetite and satiety. *Leptin* and *ghrelin* are two important hormones playing significant roles in satiety management where, the hypothalamus regulates the sensations of hunger and satiety, leading to energy homeostasis**.** Leptin, a peptide hormone, regulates food intake, body mass and reproductive functions. It also functions during proinflammatory immune response and lipolysis. It decreases hunger sensations *via* a *negative feedback mechanism* between fat cells and the hypothalamus. and ghrelin on the other hand increases them. Any imbalance in the secretion of these hormones may impact energy homeostasis and may lead to energy storage in the adipose tissues. Ghrelin and leptin exert regulatory effects with clinical significance in treating various NCDs and other disorders (Yeung and Tadi 2023; Margriet et al 2012; Tannous et al, 2006). The mechanism of these hormones on satiety and hunger and prospective weight management is shown in Figure-1.

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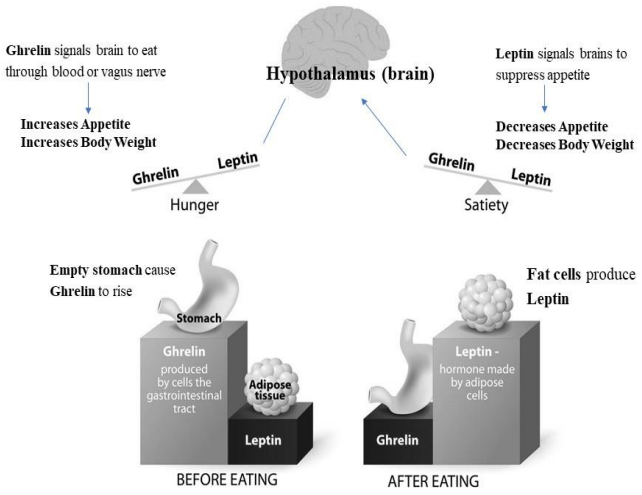

Figure 1. Mechanism of hunger and satiety hormones

Leptin Resistance and Weight Gain: A Vicious Cycle

Leptin resistance includes reduced satiety and overconsumption of calories leading to increased body mass and involves following steps cyclically.

1. ***Increased Calorie intake*:** At times, calorie-dense foods increase the calorie intake but due to lack of satiety the food intake continues.
2. ***Gain weight:*** The excess calories convert onto fat mass leading to increased leptin secretion.
3. ***Leptin Resistance***: Due to increased fat cells and leptin overload, the body loses sensitivity to leptin leading to leptin resistance.
4. ***Disrupted signal***: this leads to disruption in brain signal to initiate satiety.
5. ***Overeating:*** reduced satiety signal leads to constant craving and food intake.
   (Obradovic et al 2021)

Macronutrients (Fats, carbohydrates including fibre and protein) have varied effects on satiety signals in the human body. Amongst all the macronutrients, protein plays the most important role in maintaining satiety. Protein is a macromolecule made up of amino acids as their basic building blocks (Satyanarayana 2013). Protein has a wide range of functions and benefits in the human body like bone and muscle development, immune functions, and endocrine functions. A secondary effect of these functions is manifested as weight management and satiety. Hence, an ideal required amount of protein should be consumed every day to maintain normal protein levels in the body, mainly because they are stored in the human body.

Human Requirements of Proteins

The Recommended Dietary Allowance (RDAs) to prevent protein deficiency for an average sedentary adult range from 0.6-0.8g/Kg Body weight (Kg IBW). ICMR recommends a wide range of dietary requirements for various age groups and physiological conditions (ICMR-RDA 2020). Protein requirements are the highest among adolescents (16-18y boys) to meet the increased growth velocity including higher blood volume peak bone velocity and muscle development. Ideally, 10- 25% of the total calories every day, should come from protein. If our total calorie needs are 2000Kcal, then about 200-700 calories should come from protein (50-100gms protein per day). Protein requirements increase during

pregnancy and lactation. Endurance and strength training increase the requirements to about 2g/Kg IBW.

Protein and Satiety

Dietary sources of protein (both vegetarian and non-vegetarian) have increased capacity to maintain high satiety levels as compared to carbohydrates and fats. A higher dietary protein intake increases levels of the hormones that help maintain satiety in turn helping decrease levels of the hunger hormone. Replacing carbohydrates and fat with protein helps boost levels of hormones that maintain satiety (Astrup 2005; Margriet 2012). Higher dietary protein intake reduces appetite thereby making us consume fewer calories (Westmen 2002; Yancy 2004). High dietary protein intake can reduce hunger and appetite *via* several different mechanisms. This in turn helps to reduce the total calorie intake of individuals. As a result, people end up eating lesser calories throughout the day without counting calories and controlling portion sizes. (Joseph 2020). Research has shown that when people increase their dietary protein intake, they tend to consume fewer calories (Izadi 2014; Joesph 2020).

Mechanism of calorie control on High Protein diet

The concept of calorie reduction works on a meal basis, as well as a controlled daily reduction in calorie intake provided protein intake is kept high consistently. A general energy distribution from macronutrients is about 45-55% (% Energy) from carbohydrates, 15-30% from fats and 12-20% from proteins. Indians consume very high amounts of carbohydrates (65-80%) and very low amounts of proteins. However, when protein constitutes 30% of energy in daily diet, it helps people to achieve a reduction in total calorie intake (Gosby et al 2011; Gosby et al 2014). This sometimes is clubbed with low carbohydrates (30g/day) (Westman et al 2002). Other studies have shown that high proteins (20%E) with normal carbohydrates (50%E) and fats (30%E) could improve metabolic parameters. This suggests that weight management depends more on higher amounts of proteins than on lower amounts of other nutrients. The same is also recommended for accurate management of diabetes either as remission during early stages or prolonging the onsets (Anjana 2023). Inherently, high protein diets not only have an important role in metabolism but also in minimizing satiety, making it much easier to reduce calories compared to lower protein diets (Margriet 2012).

Dietary Protein and Appetite control

High-protein diets make us feel full for a longer time when compared with the ones constituting low-protein foods. This, therefore, makes it easier to limit calories on a high-protein diet. Protein also helps in controlling binge snacking due to food cravings. Food cravings are one of the important reasons for failures in following dietary routines. People who tend to gain weight-experience cravings so they snack and uncontrolled snacking leads to overeating which further leads to overconsumption of calories. This snacking adds to extra calories with the total calories consumed throughout the day. Dietary proteins play a very important role in the body. Some of the important functions of protein include the synthesis of other body proteins, controlling body temperature, controlling blood sugar levels and satiety. However, these processes are most distinct when the protein intake is above the dietary reference intake (20-30%E).

People who follow a high-protein diet, with 30 % of the calories coming from protein (Kayleigh et al 2019), eat less compared to people who have a normal protein intake. Protein-rich foods include fish, chicken, beans, pulses and lentils, meat, eggs, dairy products, etc. When we eat protein, its building blocks, called amino acids, need to get digested. A higher intake of protein increases the amount of amino acids in the gut thereby, increasing the process of digestion, or oxidation, of the amino acids. This increased oxidation helps boost the sensation of feeling full (Margriet et al 2012).

Satiety and Short-Term High Protein Diet

Satiety is important to induce a negative energy balance leading to increase in *fat free lean mass*. Short-term satiety is also improved with a meal that has a high protein content. Satiety is highly stimulated after consuming a high-protein meal in comparison to low protein meals, even if both high-protein meals and low-protein meals provide the same amount of calories. This is because dietary protein stimulates the secretion of satiety hormones (GIP, GLP 1), and reduces the secretion of ghrelin (an orexigenic hormone) that signals our brain that we are full (Margriet 2012).

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Protein Satiety and Diabetes

The prevalence of pre-diabetes (PD) and type 2 diabetes (T2D) has risen dramatically in recent years affecting millions of adults worldwide. There are 101 million in India and 15% of Indians are prediabetics (Anjana et al 2023). The risk of T2D increases with age, with the sharpest rise in diagnosis occurring after the age of 40 years. With age, there is also a progressive decline in muscle mass starting after the age of 30. The decline in muscle mass and function due to aging is termed sarcopenia and immediately precedes the sharp rise in T2D. A current discussed the role of protein to attenuate declines in muscle mass and insulin sensitivity to prevent T2D and sarcopenia in aging adults. The current ICMR recommended dietary allowance for protein consumption is set at 0.6-0.8 g/kg/day and is based on studies on young healthy men and may not be sufficient for older adults. Protein consumption upwards of 1.0–1.5 g/kg/day in older adults can induce improvements in glycemic control and muscle mass (Gosby et al 2011; Gosby et al 2014). The recent ICMR- INDIAB report (Anjana et al 2023) has suggested about 20% E from proteins of high quality to be effective in the management of hyperglycemia.

Effect of High Protein Diet on Blood Glucose

A high-protein diet lowers blood glucose postprandially in persons with type 2 diabetes and improves overall glucose control. However, longer-term studies are necessary to determine the total magnitude of response, possible adverse effects, and the long-term acceptability of the diet (Gannon 2003; Kayleigh et al 2019).

High Protein Diet and Weight Loss

High protein diets have been shown to be potential in weight loss as well. A diet is high in protein if it contributes to about 20% E. High protein and low carbohydrate diets are efficacious in weight management. After weight loss from an energy-restricted diet, enhancing the protein intake also increases the chance of maintaining the new body weight. Weight loss induces a decrease in energy expenditure, but an enhanced protein intake spares fat-free mass, which inhibits this decrease. Proteins also induce thermogenic effects on foods which in turn, use energy for utilization and hence provide a negative energy condition (Moon and Koh 2020).

A protein intake of more than 35% of the total calorie intake has not been shown to have any additional effect on weight loss. Therefore, it is imperative to eat a well-balanced meal comprising all macronutrients in appropriate proportions of AMDRs (Adequate Macronutrient Distribution Range). Several clinical trials have found that consuming more protein than the recommended dietary allowance not only reduces body weight (BW), but also enhances body composition by decreasing fat mass while preserving fat-free mass (FFM) in both low-calorie and standard-calorie diets. Fairly long-term clinical trials of 6–12 months reported that a high-protein diet (HPD) provides weight-loss effects and can prevent weight regain after weight loss (ICMR NIN 2020.

Protein Specific Appetite

A protein-specific appetite purportedly exists to maintain protein requirements and to prevent excess protein consumption (Tannous et al 2006). This concept is summarized by the *protein leverage hypothesis*, which suggests that a protein-specific appetite will stimulate the drive for increased food intake when the protein density of the diet is limited but will reduce the intake of diets with higher protein density (Moon and Koh 2020). This hypothesis suggests a mechanism linking dietary protein intake and energy balance.

In conclusion, an appropriate amount of protein should be included in regular diets to fight the deficiency, match up the physiological functions in normal humans and provide added benefits for people with modified physiology as in the case of obesity and diabetes.

Foods high in protein are mostly milk and milk products, animal proteins including meat and eggs, plant proteins like soya, legumes and pulses, millets and whole grains like oats. Nuts and seeds are also concentrated sources of proteins and fats (NIN IFCT 2017). Due to their high fat content nuts should be consumed in moderation about 20g/day. WHO in its recent guidelines' revision (WHO 2023) suggest that replacing saturated fatty acids with MUFA and plant proteins would help

manage NCDs like CVDs and diabetes. Plant proteins are not only sources of essential amino acids, bearing a PDCAAS of 1, which is equivalent to dairy and eggs. Their beneficial effects on many physiological functions, like immune functions, and anti-inflammatory benefits are not only due to the complete protein composition but also due to the presence of phytochemicals like isoflavones. ICMR (2020) also suggests a diet with the appropriate combination of cereal and pulses help Indians reach their protein requirements for the day. Adequate proteins help in maintaining normal functions and preventing the NCDs.

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