



Oats as a Functional Food: A Nutrient-Dense and Sustainable Strategy for Weight Management

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Abstract

Introduction-Oats (*Avena sativa* L.), a nutrient-dense cereal grain, are gaining recognition as an effective functional food for overweight or obesity management due to their unique composition, cost-effectiveness, and environmental sustainability. Their high β -glucan content (3–7 per cent), quality protein (12–17 per cent), and bioactive compounds like avenanthramides offer physiological benefits beyond basic nutrition. With obesity being a major contributor to non-communicable diseases (NCDs), particularly in developing nations undergoing rapid dietary transitions, oats provide a promising dietary strategy.

Methodology-This narrative review was conducted using literature from PubMed, ScienceDirect, and Google Scholar etc. Peer-reviewed studies including clinical trials, reviews, and in vivo/in vitro research related to oats, β -glucan, obesity, and metabolic health were analyzed and thematically synthesized.

Result-Findings show that oat β -glucan enhances satiety by (28–44 per cent), reduces LDL cholesterol by up to 15 per cent, and improves insulin sensitivity by (25–40 per cent). Its viscous nature delays gastric emptying, modulates gut hormones ($\uparrow$ PYY, $\uparrow$ GLP-1, $\downarrow$ ghrelin), and fosters beneficial gut microbiota ($\uparrow$ SCFAs, $\uparrow$ Bifidobacteria). Clinical trials report significant reductions in waist circumference and BMI z-scores in both adults and children with 3–6g/day β -glucan. Moreover, steel-cut and rolled oats retain higher molecular weight β -glucan, enhancing efficacy compared to instant forms.

Conclusion- Oats satisfy all key criteria for an ideal overweight or obesity intervention: they are affordable (\$0.10–\$0.30/serving), evidence-based, culturally adaptable, and environmentally sustainable (40 per cent lower carbon footprint vs. wheat). Their integration into daily diets offers a scalable solution to address global overweight or obesity and associated metabolic disorders, especially in low- and middle-income populations.

Keywords: Oats, β -glucan, obesity, satiety, gut microbiota, sustainable nutrition, weight management.

INTRODUCTION

Oats (*Avena sativa* L.), a cereal grain from the Poaceae family, have evolved from *Avena fatua* and are believed to have originated in parts of West Asia and ancient China. Archaeological evidence suggests that oats first appeared as a weed among barley crops during the Bronze Age (Sirotkin, 2023), before spreading throughout Central and Northern Europe. Oats have been cultivated for over 4,000 years, demonstrating remarkable adaptability to diverse climates and culinary traditions.

Oats are notable for containing the highest concentration (3–7 per cent) of β -glucan among cereals—a soluble fiber with FDA-approved health benefits for reducing non-communicable diseases (NCDs) (EFSA, 2011). Their neutral flavor, global versatility, affordability (\$0.10–0.30 per serving in low- and middle-income countries), and 30 per cent lower water requirement compared to wheat (FAO, 2022) enhance both dietary compliance and sustainability. This unique nutritional profile—rich in high-quality protein, complex carbohydrates, and bioactive compounds—positions oats as an ideal functional food for combating the global obesity epidemic (Rasane et al., 2013).

Foods that provide health advantages beyond basic nutrition by including physiologically active substances are known as functional foods (Hasler, 2002). These meals offer superior long-term compliance, a lesser risk of adverse effects, and the capacity to simultaneously affect several risk variables, in contrast to pharmacological treatments. Specifically, as a functional food, oats influence gut microbiota, metabolism, inflammation, and hunger (Sunkara & Verghese, 2014).

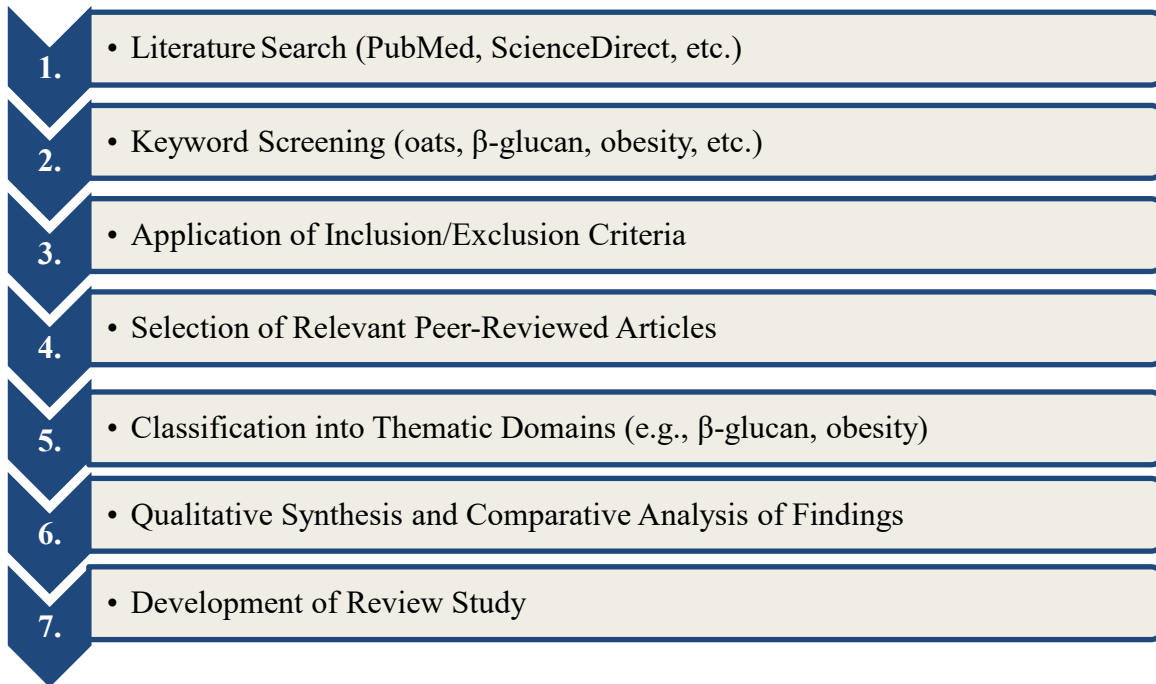
The rising global burden of non-communicable diseases (NCDs), such as cardiovascular disorders, type 2 diabetes, and metabolic syndrome, underscores the urgency for effective dietary strategies. Among these, obesity has emerged as a major public health concern, affecting 650 million adults globally, contributing to 4.7 million annual deaths through cardiometabolic complications (WHO, 2021). The prevalence of obesity has nearly tripled since 1975, with particularly alarming increases in developing countries where rapid urbanization and dietary transitions have created obesogenic environments (Ng et al., 2014). Traditional weight-loss strategies fail long-term, with 80% of individuals regaining lost weight within 5 years due to metabolic adaptations and behavioural challenges (Hall & Kahan, 2017). This high failure rate necessitates innovative approaches that address the underlying physiological and behavioural factors contributing to weight regain.

The complexity of obesity as a multifactorial disease involving genetic, environmental, and metabolic components requires comprehensive interventions that go beyond simple calorie restriction (Blüher, 2019). Sustainable weight management strategies must be economically accessible, culturally acceptable, and

environmentally responsible while providing measurable health benefits. Functional foods represent a promising approach because they can modulate multiple physiological pathways simultaneously while fitting seamlessly into existing dietary patterns (Slavin, 2013).

METHODOLOGY

This narrative review was conducted using literature from PubMed, ScienceDirect, Google Scholar, and other scholarly databases from 1999 to 2023. Keywords such as “oats,” “ β -glucan,” “obesity,” “satiety,” “antioxidant,” and “functional foods” were used. Only peer-reviewed articles including clinical trials, reviews, in vitro and in vivo studies relevant to oats and their role in metabolic health, obesity, antioxidant effects, and sustainability were included. Studies were grouped thematically and synthesized qualitatively.



RESULTS

Nutritional Profile of Oats

Oats contain a diverse range of macro and micro-nutrients along with bioactive compounds contributing to their anti-obesity effects. The detailed composition and functions are presented in table 1.

Table1: Nutritional and Functional Components of Oats and Their Anti-Obesity Role

Component	Details	Functional/Anti-obesity Role	References
Carbohydrates	60–70 per cent of total weight; 85per cent starch, 15 per cent dietary fiber	Provides energy and fiber aids in satiety	Butt et al., 2008
Protein	12–17 per cent, higher than wheat and rice; contains all essential amino acids	High biological value; supports muscle mass during weight loss	Gulvady et al., 2013
Fat	5–8per cent; rich in oleic (38–42per cent) and linoleic acid (35–40per cent)	Unsaturated fats support heart health	Welch et al., 2000
β -glucan	3–7per cent; soluble fiber; molecular weight: 50–2,000 kDa	Reduces appetite, blood glucose, cholesterol; increases satiety	Lazaridou & Biliaderis, 2007; Wood, 2007
Total Dietary Fiber	10–15per cent; soluble fiber (mainly β -glucan) = 30–40 per cent of total fiber	Improves gut health, lowers calorie absorption	Wood, 2007

Minerals	High in Mn (70per cent DV), Fe (15 per cent), Mg (12 per centf), Zn (10per cent)	Support metabolic health	USDA, 2021
B-Vitamins	Rich in B1, B2, B3, B6	Cofactors in energy metabolism	Singh et al., 2013
Avenanthramides	5–25 mg/100g	Antioxidant, anti-inflammatory; reduce oxidative stress	Bratt et al., 2003
Polyphenols	Includes flavonoids, phenolic acids, lignans	Enhance metabolic benefits and antioxidant capacity	Chu et al., 2013

The distinct macronutrient composition of oats sets them apart from other cereal grains and greatly enhances their ability to prevent obesity. The carbohydrate content of oats comprises (60–70per cent) of total weight, with approximately 85 per cent being starch and 15 per cent dietary Fiber (Butt et al., 2008). The protein content of oats ranges from (12–17 per cent), significantly higher than most cereal grains including wheat (8–12 per cent) and rice (6–8 per cent) (Gulvady et al., 2013). Oat proteins are characterized by high biological value, containing all essential amino acids in favourable proportions. Fat content in oats typically ranges from (5–8%), consisting primarily of unsaturated fatty acids, particularly oleic acid (38–42%) and linoleic acid (35–40%) (Welch et al., 2000).

β -glucan represents the most functionally significant component of oats, with concentrations ranging from (3–7 per cent) depending on variety and growing conditions. β -glucan is a water-soluble fiber composed of glucose units linked by β -(1 $\rightarrow$ 3) and β -(1 $\rightarrow$ 4) glycosidic bonds, creating a linear polysaccharide with unique rheological properties (Lazaridou & Biliaderis, 2007). The structure of oat β -(1–3) (1–4)-glucan is illustrated in figure 1. The molecular weight of β -glucan typically ranges from 50–2,000 kDa, with higher molecular weight fractions exhibiting greater viscosity and physiological activity. The total dietary Fiber content of oats ranges from (10–15 per cent), with soluble Fiber (primarily β -glucan) comprising (30–40 per cent) of total fiber content (Wood, 2007).

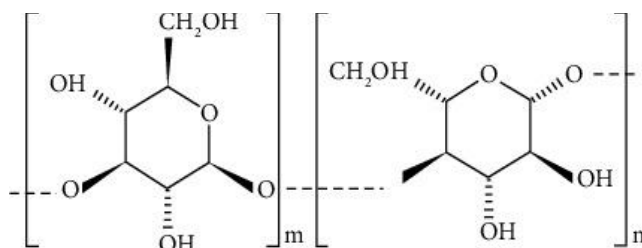


Figure 1: Structure of oat β -(1–3) (1–4)-glucan ((Alemayehu et al., 2023)

Oats are recognized as a nutrient-dense food, providing substantial quantities of essential vitamins and minerals that support metabolic health. The mineral profile includes high concentrations of manganese (providing seventy per cent of daily value per serving), iron (fifteen per cent DV), magnesium (twelve per cent DV), and zinc (ten per cent DV) (USDA, 2021). The B-vitamin content of oats is particularly noteworthy, with significant amounts of thiamine (B1), riboflavin (B2), niacin (B3), and pyridoxine (B6). These vitamins serve as essential cofactors in energy metabolism, supporting efficient conversion of macronutrients into usable energy (Singh et al., 2013).

Oats contain unique bioactive compounds that contribute to their functional properties and anti-obesity effects. Avenanthramides are phenolic compounds found almost exclusively in oats, with concentrations ranging from 5–25 mg/100g depending on variety and processing (Bratt et al., 2003). These compounds possess potent antioxidant and anti-inflammatory properties, with studies demonstrating their ability to reduce oxidative stress and inflammatory markers in clinical populations. Polyphenols in oats include various flavonoids, phenolic acids, and lignans that contribute to antioxidant capacity and metabolic benefits (Chu et al., 2013).

Clinical Evidence for Weight Management

Clinical studies in specific populations have demonstrated targeted benefits of oat consumption for overweight or obesity-related conditions. Population-based cohort studies have provided valuable insights into the long-term effects of oat consumption on weight management and metabolic health. The Nurses' Health Study, which followed 86,190 women for 26 years, demonstrated that individuals consuming whole grain oats regularly had 23 per cent lower risk of substantial weight gain (>5 kg) compared to those consuming refined grains (Liu et al., 2003). The Health Professionals Follow-up Study revealed similar benefits in men, with regular oat consumption associated with 0.8 kg less weight gain over 8-year follow-up periods after adjusting for lifestyle factors (Koh-Banerjee et al., 2004).

Clinical studies have established clear dose-response relationships for oat consumption and weight management

outcomes. The minimum effective dose appears to be 3g of β -glucan daily, equivalent to approximately 60g of rolled oats. However, optimal benefits are achieved at doses of 5-6g β -glucan daily, with diminishing returns at higher doses (Tiwari & Cummins, 2011). Timing of consumption also influences efficacy, with breakfast consumption providing superior satiety benefits compared to consumption at other meals (Geliebter et al., 2015).

In prediabetic individuals, oat interventions improved insulin sensitivity markers with 3g/day β -glucan improving HOMA-IR by 27% over 12-week periods (Tosh, 2013). Paediatric obesity studies have demonstrated that oat interventions can reduce BMI z-scores by 0.3 units ($p < 0.05$) in children aged 8-12 years, with improvements in eating behaviours and dietary quality (Johnson et al., 2020).

A research study investigated the effect of two forms of oat β -glucan which was combined with decaffeinated green coffee bean extract on obesity related biomarkers in overweight and obese individuals. Over a six-week period, four group of participants consumed a nutraceutical drink containing 3gm or 5gm of β -glucan (35-70%) along with a fixed dose of green coffee bean extract twice daily. The intervention led to significant improvement in lipid profile, glycemic control, liver enzymes, body fat percentage, anthropometric measure and blood pressure. The result of 5gm dose of 70 per cent β -glucan showed the greatest reduction in body fat and supported weight loss. (Mateos et al., 2021)

DISCUSSION

Mechanisms of Oat β -glucan in Metabolic Regulation

Oat β -glucan forms viscous gels in the stomach, increasing satiety through multiple mechanisms including gastric distension with 40 per cent slower emptying compared to refined grains, hormonal effects including increased PYY (36%), increased GLP-1 (28%), and decreased ghrelin (22%), and SCFA production where propionate activates intestinal FFAR3 receptors, suppressing appetite (Beck et al., 2010; Canfora et al., 2015 and Pino et al., 2020). Clinical data demonstrate that oatmeal breakfasts reduce ad-libitum lunch intake by 250 kcal compared to cornflakes, with satiety effects lasting up to 4 hours post-consumption (Rebello et al., 2016). The sustained satiety response is attributed to the slow digestion of β -glucan and the prolonged release of appetite-regulating hormones.

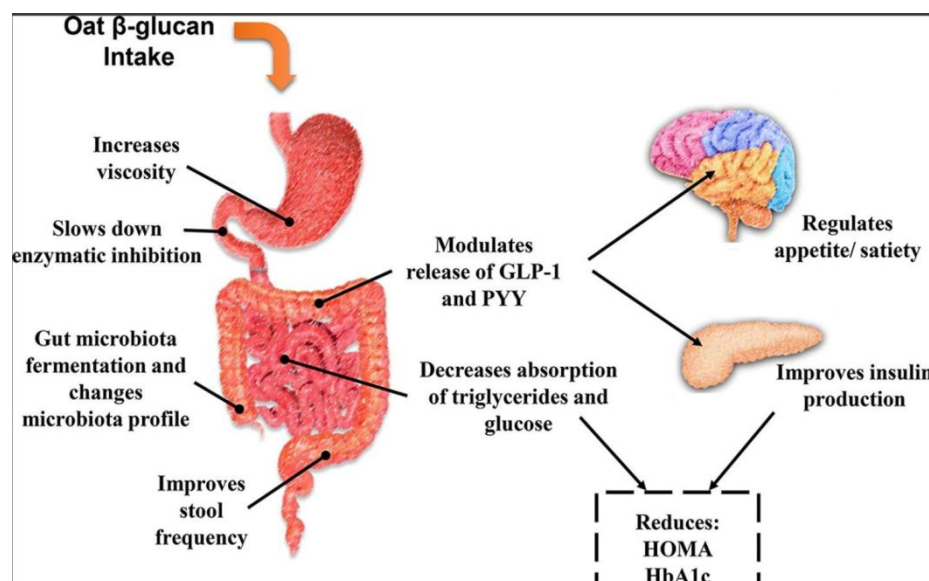


Figure 2: Mechanism of Action of Oat β -glucan (Pino et al., 2020)

Oats target visceral fat through multiple mechanisms including lipolysis enhancement where β -glucan upregulates hormone-sensitive lipase (HSL) gene expression 2.1-fold, adipogenesis inhibition as avenanthramides suppress PPAR γ activity by 40%, and inflammation reduction with decreased IL-6 (−19%) and TNF- α (−14%) in obese adults ((Bratt et al., 2003; Meydani, 2009). The preferential reduction in visceral adipose tissue is particularly significant for metabolic health, as visceral fat is strongly associated with insulin resistance, dyslipidaemia, and cardiovascular disease risk. Clinical studies have demonstrated that oat consumption results in greater reductions in waist circumference (−2.1 cm) compared to control interventions (−1.0 cm) over 12-week periods ($p = 0.008$) (Zhang et al., 2019).

β -glucan serves as a prebiotic substrate for beneficial gut bacteria, particularly Bifidobacterium and Lactobacillus species, which ferment the Fiber to produce short-chain fatty acids (SCFAs) including acetate, propionate, and butyrate (Dikeman & Fahey, 2006). These SCFAs exert multiple beneficial effects on host metabolism, including enhanced insulin sensitivity, reduced inflammation, and improved appetite regulation. Clinical studies have demonstrated that oat consumption significantly increases Bifidobacterium populations by 35-45 per cent and total SCFA production by 25-30 per cent within 4-6 weeks of intervention (Xu et al., 2017). The production of propionate specifically has been linked to appetite suppression through activation of intestinal FFAR3 receptors, which stimulate the release of GLP-1 and PYY (Canfora et al., 2015).

Oat consumption significantly improves glycaemic control through multiple mechanisms, including delayed

gastric emptying, reduced glucose absorption, and enhanced insulin sensitivity. Clinical studies in prediabetic individuals have demonstrated that 3g/day β -glucan improves insulin sensitivity (HOMA-IR) by 25-40 per cent over 12-week interventions (Tosh, 2013). The viscous properties of β -glucan create a physical barrier that slows glucose absorption, resulting in reduced postprandial glycaemic responses and lower insulin demand (Wolever et al., 2010).

The antioxidant capacity of oats is attributed to their unique content of avenanthramides, which demonstrate 10-30 times greater antioxidant activity than other common cereal phenolics (Emmons & Peterson, 1999). Clinical studies have shown that oat consumption reduces systemic inflammation markers, including C-reactive protein (CRP) by 19 per cent and interleukin-6 (IL-6) by 14 per cent in obese adults (Meydani, 2009). The anti-inflammatory effects of oats are particularly relevant for obesity management, as chronic low-grade inflammation is a hallmark of metabolic dysfunction and contributes to insulin resistance and cardiovascular disease risk (Hotamisligil, 2006).

Practical Implementation Strategies

The minimum effective dose for weight management benefits is three gram β -glucan daily, equivalent to approximately sixty gram of rolled oats or forty gram of oat bran. For optimal results, this dose should be divided across meals, with breakfast consumption providing the greatest satiety benefits. Clinical studies demonstrate that consuming oats as the first meal of the day enhances appetite control and reduces subsequent food intake by fifteen to twenty per cent (Rebello et al., 2016). The timing of oat consumption relative to exercise may also influence outcomes, with consuming oats 2-3 hours before exercise providing sustained energy release and enhancing fat oxidation during physical activity (Arent et al., 2010).

The processing method significantly impacts the functional properties of oats and their efficacy for weight management. Instant oats should be avoided as milling reduces β -glucan molecular weight from 2,000 kDa to 300 kDa, decreasing viscosity by sixty per cent and reducing physiological activity (Wood, 2007). The recommended processing hierarchy for maintaining β -glucan integrity is steel-cut oats > rolled oats > quick oats > instant oats. Cooking methods also influence β -glucan functionality, with gentle cooking methods that preserve Fiber structure, such as overnight soaking or slow cooking, maintaining optimal viscosity and physiological activity (Tiwari & Cummins, 2011).

The successful implementation of oat-based interventions requires adaptation to local culinary traditions and taste preferences. Regional adaptations have been developed to enhance acceptability, including congee-style savory oat porridge in Asia, oat-fortified injera (teff blend) in Africa, and avena-based smoothies with chia in Latin America (FAO, 2023). Product development strategies should focus on incorporating oats into familiar food formats while maintaining their functional properties, including developing oat-based noodles, bread products, and snack foods that provide the benefits of β -glucan while fitting into existing dietary patterns (Rasane et al., 2015).

Standardization of oat products for weight management applications requires attention to β -glucan content, molecular weight, and processing methods. Quality control measures should include verification of β -glucan content through enzymatic assays and assessment of molecular weight through size exclusion chromatography. Products intended for weight management should contain minimum 3g β -glucan per serving with molecular weight >1,000 kDa. Storage conditions significantly impact β -glucan stability, with optimal preservation achieved through cool, dry storage conditions and minimal exposure to light and oxygen (Wood, 2007).

Sustainability and Economic Considerations

Oats represent one of the most environmentally sustainable cereal crops, with significantly lower environmental impact compared to animal protein sources and many other grains. The carbon footprint of oat production is approximately 40% lower than wheat, attributed to lower fertilizer requirements and efficient water utilization (Clarke et al., 2017). Water requirements for oat production are thirty per cent lower than wheat and fifty per cent lower than rice, making oats particularly suitable for regions with water scarcity. The nitrogen fixation capacity of oats in rotation systems contributes to soil health and reduces the need for synthetic fertilizers. Life cycle assessments demonstrate that oat-based diets have sixty five per cent lower greenhouse gas emissions compared to diets high in animal protein while providing comparable nutritional benefits (Hallström et al., 2015).

The economic accessibility of oats makes them an attractive option for population-level interventions. The cost per serving ranges from \$0.10-0.30 in low- and middle-income countries, making oats one of the most cost-effective sources of high-quality nutrition (FAO, 2023). The favourable cost-benefit ratio is particularly pronounced when considering the healthcare cost savings associated with obesity prevention and metabolic health improvement. Economic modelling studies suggest that oat-based interventions could reduce healthcare costs by \$1,200-2,400 per person over ten-year periods through reduced incidence of diabetes, cardiovascular disease, and obesity-related complications (Gyles et al., 2010).

Global oat production capacity is approximately twenty-eight million tons annually, with potential for significant expansion in response to increased demand (FAO, 2023). The adaptability of oats to diverse climatic conditions and marginal soils makes them suitable for cultivation in regions where other crops may not thrive. Investment in oat processing infrastructure and value-added product development could create economic opportunities in rural communities while supporting public health objectives (Rasane et al., 2015).

Table 2: Sustainability and Economic Indicators of Oats

Parameter	Oats	Comparison/Significance	References
Carbon Footprint	~40 per cent lower than wheat	Due to lower fertilizer use and efficient growth	Clarke et al., 2017
Water Requirement	30 per cent less than wheat, 50% less than rice	Ideal for water-scarce regions	Clarke et al., 2017
Soil Health	Nitrogen-fixing rotation crop	Reduces synthetic fertilizer needs	Clarke et al., 2017
GHG Emissions from Diets	65 per cent lower in oat-based diets	Compared to animal-protein-based diets	Hallström et al., 2015
Cost per Serving	\$0.10 – \$0.30	Affordable in low- and middle-income countries	FAO, 2023
Healthcare Cost Savings	\$1,200 – \$2,400 per person (over 10 years)	Due to reduced overweight or obesity and metabolic diseases	Gyles et al., 2010
Global Production Capacity	~28 million tons annually	High adaptability to expand further	FAO, 2023
Cultivation Suitability	Thrives in marginal soils and varied climates	Suitable for diverse agricultural regions	Rasane et al., 2015
Economic Opportunity	Encourages rural development through processing and value addition	Aligns with both health and economic development goals	Rasane et al., 2015

Conclusion

Due to its high β -glucan content, oats provide an economical, sustainable, and scientifically validated functional meal for managing overweight or obesity. They are an effective dietary aid in the fight against overweight or obesity and its associated metabolic diseases because of their capacity to increase satiety, improve insulin sensitivity, lower inflammation, and support gut health. Clinical evidence affirms the efficacy of oats in reducing body weight, visceral fat, and appetite when consumed in optimal doses and forms. Additionally, their low environmental impact and ability to adapt to a variety of cuisines make them more feasible for population-wide therapies. Continued research on personalization, synergistic combinations, and product development will further advance oats as a core component of nutritional strategies for global health.

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