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Aarogyam Aanandam Aashirvadam

iGD Institute for Global Development

Opportunities with **Whole Grains** to Support Metabolic Health among Indians : Evidence Mapping

A WHITE PAPER

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Opportunities with Whole Grains to Support Metabolic Health among Indians: Evidence Mapping

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PREFACE

Whole Grains (WG) have always been a part of Indian meals, and their consumption is deeply rooted in our culture. They have been the cornerstone of Indian dietary practices for decades, providing essential nutrients, dietary fiber, and sustained energy. However, rapid urbanization, dietary transitions, and increased consumption of refined grains have gradually displaced whole grains from Indian plates. As a result, there are concerns about nutrition security and the growing burden of non-communicable diseases among Indians.

Whole grains are an imperative part of healthy and sustainable diets. They are the source of complex carbohydrates, dietary fiber, vitamins, minerals, and bioactive compounds. Empirical evidence suggests that whole grains have a significant effect on metabolic health including, chronic diseases like digestive malfunctions, hyper glycemia, hyperinsulinemia, obesity, diabetes, cardiovascular disease, respiratory and cognitive functions. Vulnerable populations, including adolescents, pregnant women, and lactating mothers, have inadequate intakes of whole grains; thereby, increasing the risk of micronutrient deficiencies, poor dietary diversity, and sub-optimal growth and development overall leading to higher risks for metabolic health conditions.

Lack of awareness and understanding of whole grains is a major limiting factor in their adequate consumption. Apart from consumers, policymakers, and health professionals also have limited comprehensive knowledge about the benefits and sources of whole grains. The challenges of promoting whole grains in communities are largely complicated by the lack of standardized labeling of whole grains on packaged products, and the increased demand and consumption of refined grain products.

Our white paper, **the first in India**, provides a comprehensive overview of whole grains in the Indian context. The authors, with their diverse and wholesome expertise on WG, bring together the critical elements of scientific literature, policy guidelines, and recommendations on whole grains, including definitions, health benefits, dietary sources, and recommended intake. Furthermore, the paper aims to clarify common misconceptions about whole grains, easy to understand ways of identifying Whole grains and to highlight current actionable recommendations to improve their awareness and intake across different population groups in India.

I want to thank **ITC Ltd, Foods Business Division**, for the generous and relentless support in the publication and release of this white paper. I hope this white paper will contribute to informed dialogue, evidence-based policy action, and collective efforts to reintegrate whole grains into the daily diets of the Indian population.

Dr. Shashank Bhalkar
Executive Director
Protein Foods and Nutrition Development Association of India (PFNDAI)

EXECUTIVE SUMMARY

Non-communicable diseases, such as obesity, hypertension, diabetes, and cardiovascular diseases, are on a gradual rise globally, but steeply in India. Indians are affected largely by non-communicable diseases due to poor metabolic health and dietary habits. Our white paper was launched to highlight different varieties of cereals that fall under the umbrella of whole grains, along with their nutritional profiles, health benefits, recipes based on their combinations, and myths associated with their poor consumption.

The term '**whole grain'** refers to the entire seed of cereals or pseudo-cereals, which are edible and made of bran, germ, and endosperm. **FSSAI** defines whole grain as, '*whole grains consist of the intact, ground, cracked, flaked, or otherwise processed kernel after the removal of inedible parts such as the hull and husk.*' The umbrella of whole grains includes wheat, wild rice, brown rice, colored rice, corn, millets, sorghum (milo), barley, rye, oats, and teff. Pseudo-cereals, higher in protein, include amaranth, buckwheat, and quinoa. **Whole grains** are sources of different micronutrients, such as vitamin B1, vitamin B6, folate, zinc, phosphorus, magnesium, manganese, niacin, selenium, iron, etc.

Processing whole grains, such as washing, cleaning, removal of inedible parts (husks/hulls), dry milling, sifting, and wet processing, makes them more palatable, with improved nutrient bioavailability and storage stability. However, **mechanical removal of bran and germ** results in the loss of fiber, vitamins, and minerals like magnesium. The consumption of refined grains makes people prone to heart disease, type 2 diabetes, and obesity due to a lack of fiber, vitamins, and minerals.

Products labeled '**Whole Grain'** would have a higher percentage of whole grains and must meet certain standards as ordained by the certifying organization or governing body. FSSAI-compliant, packaged whole grains (e.g., wheat, rice, and oats) must display the product name, ingredients

(descending order), nutritional facts, net weight, FSSAI logo/license number, manufacturer details, batch/lot number, date of packing, and "Best Before" date.

Regular **consumption of variety of whole grains** is proven to reduce total and LDLc (Low Density Lipoproteins cholesterol; bad cholesterol), reduces the risk of coronary heart disease, cardiovascular disease, all-cause mortality, and mortality from stroke and diabetes, regulates glucose and insulin levels, supports weight management by enhancing satiety and influencing energy balance, and lastly, protects against major chronic diseases. The consumption of whole grains is less than 10% (42 g/day) of the total grain consumption (432g/day).

The **major barriers to the consumption of whole grains** include a dislike of their taste/texture, poor availability of whole-grain foods, their cost, the time-consuming process of preparing and eating them, chewing difficulties, and a lack of knowledge about their nutritional and health benefits. Some of the critical ways to promote their consumption include increasing the availability and the variety of foods containing whole grains, improving their sensory appeal, reducing their purchasing cost, and using a familiarization period to introduce them to consumers (with a gradual increase in consumed amounts and repeated exposure), and lastly, improving communication and labelling.

Expert-led collaborations between policymakers, industry and non-governmental organizations (NGOs), must prioritize fortified WG flours, digital recipe tools, and surveyed pilots to propel national intake from 10g /day to the ICMR (NIN - DGI) recommended 125g/d, capitalizing on India's 20+ millet varieties for enduring impact

Lastly, the white paper highlights key recommendations for the policy makers, academicians, and public health specialists to promote the consumption of whole grains through co-creating innovative and tasty whole-grain-based recipes, generate awareness in communities about whole grains, dispel myths and misconceptions associated with them, counsel women, and other vulnerable populations about the health benefits of whole grains. Nutritionists and clinicians should research more on the precise effect of whole grains on different blood and body parameters, with sustained improvement in the overall health of children and adults.

CONTENTS

LIST OF TABLES & FIGURES

Tables

Figures

LIST OF ABBREVIATIONS

AAA	:	Aarogyam Aanandam Aashirvadam
BMI	:	Body Mass Index
CVD	:	Cardiovascular Diseases
CRP	:	C-Reactive Protein
FCWG	:	Food containing Whole Grains
FDA	:	Food and Drug Administration
FSSAI	:	Food Safety and Standards Authority of India
GLP	:	Glucagon-Like Peptide
ICMR	:	Indian Council of Medical Research
HCES	:	Household Consumption Expenditure Survey
HFSS	:	High Fat Sugar and Salt
LDL	:	Low-Density Lipoproteins
LRE	:	Limited Ready-to-Eat
NCD	:	Non-Communicable Diseases
NIN	:	National Institute of Nutrition
NNMB	:	National Nutrition Monitoring Bureau
NSSO	:	National Sample Survey Organization
PDS	:	Public Distribution System
RCT	:	Randomized Controlled Trials
T2D	:	Type-2 Diabetes
WG	:	Whole Grain

SECTION I

KNOW YOUR WHOLE GRAINS

Author: **Sridevi Annapurna Singh**

Overview

In **Section I**, we introduce the definition of whole grains, the different cereals that fall under the umbrella of whole grains, highlight the differences between whole grains and refined grains, and build an understanding of the labeling of whole grains to select whole-grain-based foods.

Objectives of Section I

1. To explain the structural components of whole grains
2. To define whole grains using global and Indian perspectives and understand the nutritional profiling of different whole grain varieties
3. To list common whole grain foods and differentiate whole grains from refined grains
4. To understand the whole grain processing steps and different whole-grain-based products
5. To explain the labelling of whole grain-based products
6. To create educational material for informing beneficiaries about whole grain anatomy, common varieties of whole grains, and the practice of reading the labels on packaged products about whole grain claims

1.1 Grain's Anatomy

The small, hard, and dry fruit (seeds) or caryopsis harvested from food crops are called grains. Grains or kernels may or may not have an inedible hull; grains protected by hulls have a good shelf life as the hull prevents damage to the grain by water, pests, or microorganisms. Plant seeds are the repositories of nutrients and have high contents of both macro and micronutrients. The macronutrients include carbohydrates, protein, and fat, while micronutrients include vitamins and minerals. These are present in higher or lower quantities depending on the seed. Generally, cereals and pseudocereals have higher carbohydrate contents, while pulses and oilseeds have higher protein and fat contents, respectively. There are three layers in the structure of an edible kernel (**Figure 1**).

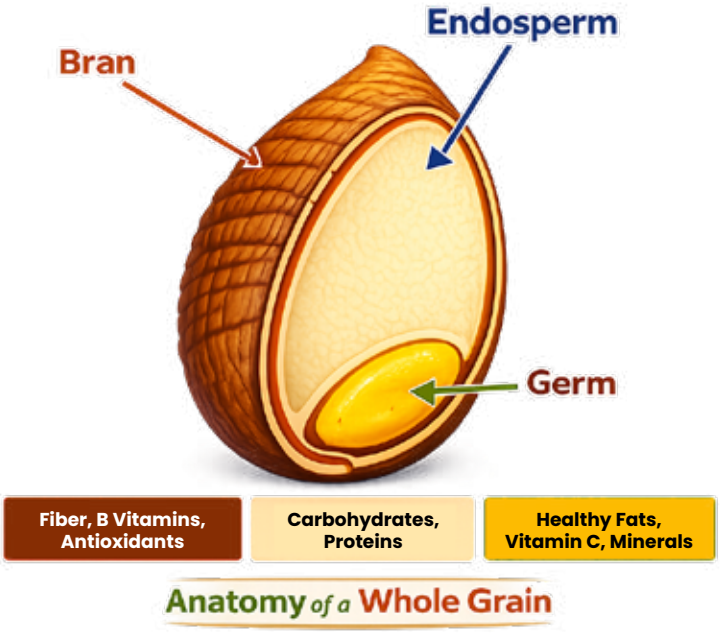

Figure 1. The structure of a whole grain

(Source: Illustration generated using an AI image generation tool based on a reference image of grain anatomy; prepared by ChatGPT AI Tool (2026)

1.2 Definition of Whole Grains

Cereal grains, obtained from grasses (*Poaceae*), are monocot seeds that are consumed as staples globally. They include rice, corn, wheat, etc. Pseudocereals, including amaranth, buckwheat, and quinoa, are dicot seeds and therefore do not belong to the grass family. However, pseudocereals have higher protein but are processed very similarly to cereals, have similar nutritional profiles and preparation (as cereals), and are also consumed as staples. Pulses, a source of proteins for vegetarians, and oilseeds, a source of fat, are dicots and are not classified as grains. The Whole Grain Council, the Cereals and Grains Association (formerly known as American Association of Cereal Chemists; AACC International), and the US Food and Drug Administration (FDA) do not recognize oilseeds and legumes as whole grains.

The term '**whole grain**' refers to the entire seed of cereals or pseudocereals, which are edible and made of bran, germ, and endosperm. Bran is the multilayered outer skin of the kernel. The bran is often a very important source of fiber, antioxidants, and B vitamins. The **germ** refers to the embryo and is also a very good source of minerals, fats, protein, and B vitamins. The major portion of the kernel is the endosperm, which consists of the stored nutrients for feeding the germ. The endosperm consists of carbohydrates, proteins, fat, vitamins, and minerals.

As per the **Whole Grain Council,** the definition of whole grain is as follows:

'Whole grains shall consist of the intact, ground, cracked, flaked, or otherwise processed kernel after the removal of inedible parts such as the hull and husk. All anatomical components, including the endosperm, germ, and bran, must be present in the same relative proportions as in the intact kernel.'

This definition means that 100% of the original kernel – all the bran, germ, and endosperm – must be present to qualify as a whole grain.

The offcial definition of whole grains, approved and endorsed by the **Whole Grains Council** in May 2004 is as follows:

'Whole grains or foods made from them contain all the essential parts and naturally occurring nutrients of the entire grain seed in their original proportions. If the grain has been processed (e.g., cracked, crushed, rolled, extruded, and/or cooked), the food product should deliver the same rich balance of nutrients that are found in the original grain seed.'

The **US FDA** defines whole grains as consisting of the ***"intact, ground, cracked, or flaked fruit of the grains whose principal components—the starchy endosperm, germ, and bran —are present in the same relative proportions as they exist in the intact grain."***

The **Whole Grain Initiative** congregated an international working group with more than 40 expert members from government agencies, industries, and academia across Europe, North and South America, Africa, Asia, and Oceania so that '*A consensus on a global definition of whole grain (as raw material) and on the definition of a whole grain food*' could be reached. The working group considered and debated new developments in breeding, processing technologies, and markets worldwide, the needs and wishes of consumer organizations for whole grain-related regulations and labelling, as well as widely accepted definitions. Further, the deliberations also considered actions by regulatory authorities who are developing whole grain definitions, too.

The key statements of the definition documents are: ***"Whole grains shall consist of the intact, ground, cracked, flaked or otherwise processed kernel after the removal of inedible parts such as the hull and husk; all anatomical components, including the endosperm, germ, and bran must be present in the same relative proportions as in the intact kernel."***

and

"A whole-grain food shall contain at least 50% whole-grain ingredients based on dry weight. Foods containing 25–50% whole-grain ingredients based on dry weight may make a front-of-pack claim on the presence of whole grain but cannot be designated 'whole grain' in the product name." The definition documents have been ratified by the leading international scientific associations in this area.

Nationally representative dietary intake surveys indicate that consumption of whole grains is below recommended values, even though higher whole grain intake is associated with health benefits. Both the **Whole Grain Ingredient** and **Whole-Grain Food** definitions have been ratified by the leading international cereal science associations, including the **Cereals and Grains Association**, the **Health grain Forum**, and the **International Association for Cereal Science and Technology (ICC)**.

The **Whole Grain Initiative's** definitions working group, in collaboration with the Whole Grain Initiative leadership team, is working across countries and regulatory authorities to advocate for adoption of these definitions globally. Recombination, reconstitution, and other new processes are allowed by consensus definitions if manufacturing practices ensure quality. This is done to ensure safe and sensorily acceptable whole grain products that include processes apart from grinding, cracking, and flaking that are mentioned in previous definitions of whole grains. For malting and sprouting, the definition and conditions set by the **Cereals and Grains Association** and the **Health Grain Forum** stipulate that the length of the sprout does not exceed the kernel length and there is no change in the nutritional value.

Due to the presence of higher amounts of mycotoxins, agrochemicals, and microbial contaminants in the outer pericarp layer of grain, removal of a minor part of the kernel is included in some

definitions (**Health Grain**) that is adopted by Germany, Switzerland, and Denmark. The definition states that '*Small losses of components – that is, less than 2% of the grain/ 10% of the bran – that occur through processing methods consistent with safety and quality are allowed*'. It must be noted that no quantitative limit is included in the global definition due to the large variations worldwide in grain variety, local regulations, and constraints. However, '*allowable limits for the percentage removed should be evidence-based and be kept to a minimum.*'

In India, the Food Safety and Standards Authority of India (**FSSAI)** defines whole grain as, '*whole grains consist of the intact, ground, cracked, flaked, or otherwise processed kernel after the removal of inedible parts such as the hull and husk. All anatomical components, including the endosperm, germ, and bran, must be present in the same relative proportions as in the intact kernel.*' The definition is applicable to all edible cereal and pseudocereal grains.

1.3 Common whole grain foods

The current list of whole grains that are well known and accepted includes (*list is not comprehensive but representative*) (**Figure 2-4**):

- Wheat – Spelt, farro, emmer, einkorn, *kamut, durm*, bulgar, cracked wheat, wheatberries
- Rice – wild rice, brown rice, and colored rice
- Corn
- Millets
- Sorghum (milo)
- Barley
- Rye
- Oats
- Teff

Pseudo-cereals

- Amaranth (*Amaranthus caudatus* L, *Amaranthus cruentus* L, *Amaranthus hypochondriacus* L)
- Buckwheat
- Quinoa

There are many grains that are largely unchanged since hundreds of years and considered **ancient grains**. These include einkorn, emmer/farro, Kamut®, millets, black barley, red, wild, and black rice, blue corn, teff, sorghum, quinoa, amaranth and so on. Modern wheat and grains that are selectively bred for specific traits and released for cultivation are not.

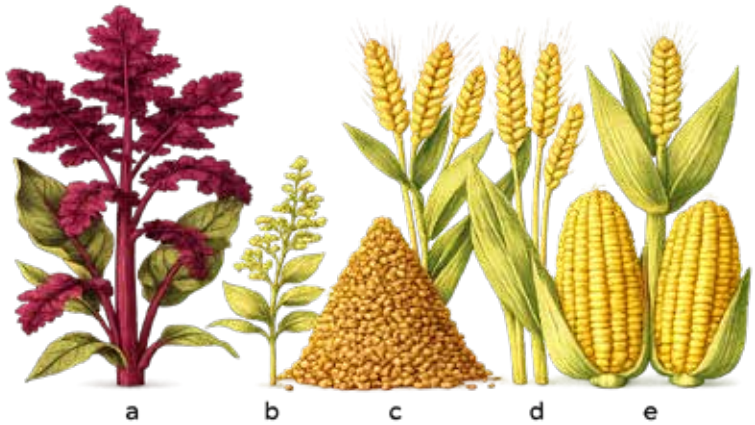

Figure 2. Illustrations of common whole grains, including a. Amaranth, b. Barley, c. Buckwheat and bulgur, d. and e. Corn

(Source: Illustration generated using an AI image generation tool based on a reference image of grain anatomy; prepared by ChatGPT AI tool (2026)

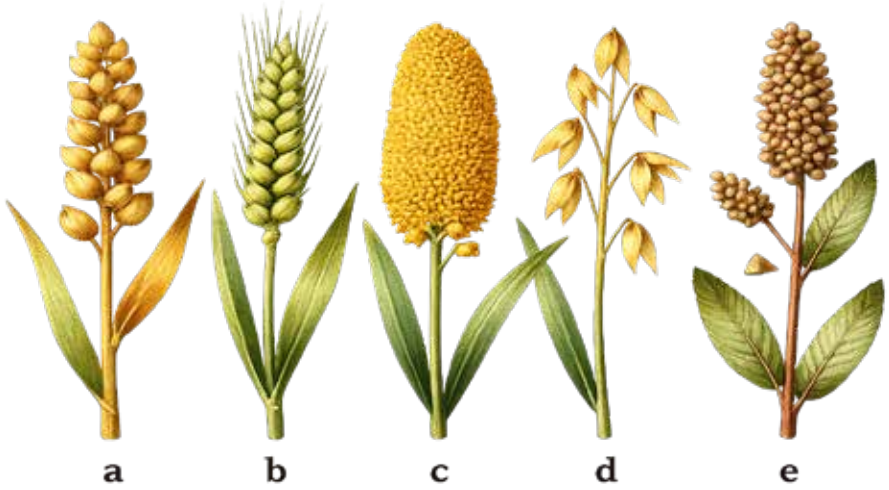

Figure 3. Illustrations of common whole grains, including a. Fonio, b. Freekeh, c. Millet, d. Oats, e. Quinoa

(Source: Illustration generated using an AI image generation tool based on a reference image of grain anatomy; prepared by ChatGPT AI Tool (2026))

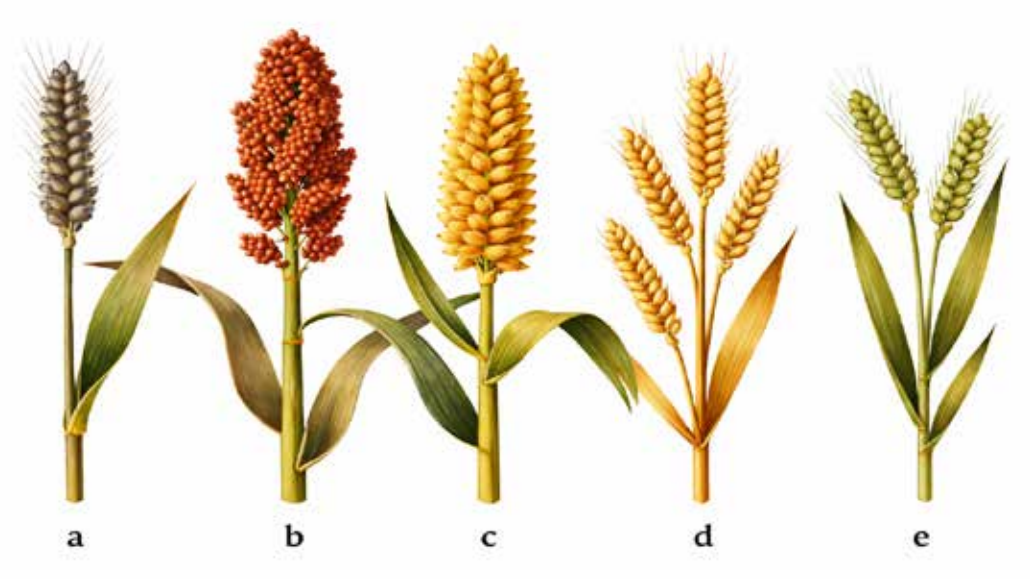

Figure 4. Illustrations of common whole grains, including a. Rye, b. Sorghum, c. Whole wheat, d. Wild rice, e. Teff

(Source: Illustration generated using an AI image generation tool based on a reference image of grain anatomy; prepared by ChatGPT (2026))

1.4 Nutrition profile and products developed from whole grains

The different varieties of grains include wheat, brown and wild rice, millets, oats, rye, quinoa, etc. Whole grains are sources of different micronutrients, such as vitamin B1, vitamin B3, folate, zinc, phosphorus, magnesium, selenium, etc. (**Table 1**). Different definitions have been proposed for whole grains and their products globally (**Table 2**).

Table 1. Nutritional profile and uses of whole grains

Grain Varieties	Nutritional Profile	Uses	Gluten/ Gluten free
Whole Wheat Triticum aestivum	Per half-cup (60g) serving of whole wheat flour provides: ▪ Calories: 204 kcal ▪ Carbohydrate: 43.2 g ▪ Fiber: 6.4 g ▪ Sugars: 0.25 g ▪ Fat: 1.5 g ▪ Protein: 7.95 g Manganese, selenium, phosphorus, thiamin (B1), and magnesium	Baking, bread, flour, pasta, thickening sauces	Not gluten-free
Brown rice *Oryza sativa*	Per cup (202g) of cooked brown rice provides: ▪ Calories: 248 kcal ▪ Carbohydrate: 51.7 g ▪ Fiber: 3.23 g ▪ Sugars: 0.46 g ▪ Fat: 1.96 g ▪ Protein: 5.54 g Manganese, niacin (B3), thiamin (B1), phosphorus, and magnesium	Baked goods, cooked rice, flour, rice-based dishes	Gluten-free
Wild rice *Zizania*	A cup of cooked rice (~173 g) provides: ▪ Calories: 166 kcal ▪ Carbohydrate: 35.0 g ▪ Fiber: 2.95 g ▪ Sugars: 1.2 g ▪ Fat: 0.56 g ▪ Protein: 6.54 g Manganese, zinc, phosphorus, magnesium, and vitamin B6	Baked goods, cooked rice, flour, mixed rice dishes	Gluten-free

Grain Varieties	Nutritional Profile	Uses	Gluten/ Gluten free
Oats *Avena sativa*	Per cup (81g) serving of oats provides: ▪ Calories: 307 kcal ▪ Carbohydrate: 54.8 g ▪ Total fiber: 8.18 g ▪ Sugars: 0.8 g ▪ Fat: 5.28 g ▪ Protein: 10.7 g Manganese, selenium, phosphorus, magnesium, and thiamin (B1); Groats (the whole oat kernel), steel-cut oats (cut kernels), and rolled oats (steamed and flattened groats)	Baking, beer, bread, flour, porridge	Naturally gluten-free; Contains avenin, a protein some people are allergic to it
Maize (corn) *Zea mays*	A large ear of cooked corn (118g) provides: ▪ Calories: 113 kcal ▪ Carbohydrate: 24.8 g ▪ Fiber: 2.83 g ▪ Sugars: 3.23 g ▪ Fat: 1.77 g ▪ Protein: 4.0 g Folate, phosphorus, manganese, magnesium, and potassium	Baking, bread, corn on the cob, corn oil, corn syrup, flour, sweet corn	Gluten-free
Millets *(Different millets are present with varying nutritional composition)*	Per cup (174g) serving of cooked millet provides: ▪ Calories: 207 kcal ▪ Carbohydrate: 41.2 g ▪ Fiber: 2.26 g ▪ Sugars: 0.23 g ▪ Fat: 1.74 g ▪ Protein: 6.11 g All vitamins and minerals in different proportions depending on the grains; Millets include Ragi, Bajra, Jowar (sorghum), Little millet, Foxtail millet, Barnyard millet, Brown top millet, Job's tears, Fonio, Proso millet, and Kodo millet	Bread, flour-based snacks, alcoholic beverages, dumplings, etc.	Gluten-free

Grain Varieties	Nutritional Profile	Uses	Gluten/ Gluten free
Barley *Hordeum vulgare*	Cooked pearled barley per cup (157g) provides: ▪ Calories: 193 kcal ▪ Carbohydrate: 44.3 g ▪ Fiber: 5.97 g ▪ Sugars: 0.44 g ▪ Fat: 0.69 g ▪ Protein: 3.55 g Manganese, selenium, niacin (B3), phosphorus, and magnesium	Beer, bread, flour, malt drinks, porridge, soups and stews, tea	Not gluten-free
Freekeh *Triticum turgidum var. durum*	A quarter-cup (40-gram) serving of freekeh provides (24): ▪ Calories: 130 kcal ▪ Carbohydrate: 28.0 g ▪ Fiber: 4.0 g ▪ Sugars: 0 g ▪ Fat: 1.0 g ▪ Protein: 6.0 g Manganese, iron, phosphorus, niacin (B3), and folate	Bread, flour, mixed dishes, served alone, soups, and stews	Not gluten-free
Emmer (Khapli Wheat) *Triticum turgidum*	A quarter cup (47g) serving of emmer flour provides: ▪ Calories: 170 kcal ▪ Carbohydrate: 34.0 g ▪ Fiber: 4.98 g ▪ Fat: 1.0 g ▪ Protein: 6.0 g Manganese, selenium, magnesium, thiamin (B1), and phosphorus	Baking, bread, cakes, flour	Not gluten-free

Grain Varieties	Nutritional Profile	Uses	Gluten/ Gluten free
Einkorn *Triticum monococcum*	Per quarter cup (48g) serving of einkorn flour provides: ▪ Calories: 160 kcal ▪ Carbohydrate: 31.0 g ▪ Fiber: 2.98 g ▪ Sugars: 0.99 g ▪ Fat: 0.99 g ▪ Protein: 8.0 g Manganese, selenium, magnesium, thiamin (B1), and phosphorus	Baking, bread, cakes, flour	Not gluten-free
Rye *Secale cereale*	Per one-third cup serving of rye grains provides: ▪ Calories: 190 kcal ▪ Carbohydrate: 42.7 g ▪ Fiber: 8.5 g ▪ Sugars: 0.55 g ▪ Fat: 0.92 g ▪ Protein: 5.8 g Manganese, phosphorus, magnesium, niacin (B3), and thiamin (B1)	Baking, beer, bread, flour, mixed dishes, served alone as cooked rye berries	Not gluten-free
Bulgur *Triticum durum*	Per cup (182g) serving of Bulgur provides: ▪ Calories: 151 kcal ▪ Carbohydrate: 33.8 g ▪ Fiber: 8.19 g ▪ Sugars: 0.182 g ▪ Fat: 0.437 g ▪ Protein: 5.61 g Manganese, magnesium, phosphorus, niacin (B3), and copper	Bread, flour, porridge, rice replacement, soups, and stews	Not gluten-free

Grain Varieties	Nutritional Profile	Uses	Gluten/ Gluten free
Khorasan (Kamut) *Triticum turanicum*	A cup (172g) serving of cooked *khorasan* provides: ▪ Calories: 227 kcal ▪ Carbohydrate: 47.5 g ▪ Fiber: 7.4 g ▪ Sugars: 5.28 g ▪ Fat: 1.43 g ▪ Protein: 9.8 g Thiamin (B1), phosphorus, iron, manganese, and niacin (B3)	Baking, bread, flour, soups, stews, thickening sauces	
Spelt *Triticum spelta*	Per cup serving (~194 g) of cooked spelt provides: ▪ Calories: 246 kcal ▪ Carbohydrate: 51.3 g ▪ Fiber: 7.57 g ▪ Fat: 1.65 g ▪ Protein: 10.7 g Manganese, phosphorus, magnesium, niacin (B3), and copper	Baking, beer, bread, flour, mixed meals, and spelt salads	Not gluten-free
Triticale *Triticale hexaploide Lart*	Per one-third cup (~64 g) serving of triticale provides: ▪ Calories: 215 kcal ▪ Carbohydrate: 46.2 g ▪ Fat: 1.3 g ▪ Protein: 8.35 g Manganese, phosphorus, magnesium, thiamin (B1), and zinc	Baking, bread, flour, thickening sauces	Not gluten-free

Grain Varieties	Nutritional Profile	Uses	Gluten/ Gluten free
Sorghum *Sorghum bicolor*	Per one-third cup serving of sorghum grains provides: ▪ Calories: 211 kcal ▪ Carbohydrate: 46.0 g ▪ Fiber: 4.3 g ▪ Sugars: 1.62 g ▪ Fat: 2.21 g ▪ Protein: 6.8 g Manganese, magnesium, phosphorus, vitamin B6, and thiamin (B1)	Baking, beer, bread, flour, porridge	Gluten-free
Teff *Eragrostis tef*	Per cup (~252 g) serving of cooked teff provides: ▪ Calories: 255 kcal ▪ Carbohydrate: 50.0 g ▪ Fiber: 7.06 g ▪ Fat: 1.64 g ▪ Protein: 9.75 g Manganese, magnesium, phosphorus, iron, and copper	Baking, beer, bread, flour, mixed dishes, porridge, soups, stews	Gluten-free
Fonio *Digitaria exilis, Digitaria iburua*	Per 100g serving of Fonio provides: ▪ Calories: 335 kcal ▪ Carbohydrate: 66.1 g ▪ Fiber: 18.2 g ▪ Fat: 4.2 g ▪ Protein: 8.5 g Iron, magnesium, riboflavin, thiamin, and zinc	Baking, beer, bread, couscous, flour, porridge, rice alternative	

Grain Varieties	Nutritional Profile	Uses	Gluten/ Gluten free
Amaranth *Amaranthus caudatus L, Amaranthus cruentus L, Amaranthus hypochondria-cus L*	Cooked grain nutritional profile (246 g) provides: ▪ Calories: 251 kcal ▪ Carbohydrate: 46.0 g ▪ Fiber: 5.17 g ▪ Fat: 3.89 g ▪ Protein: 9.35 g Manganese, magnesium, phosphorus, iron, and vitamin B6	Flour, mixed with rice, porridge, soups, stews, and thickening sauces	Gluten-free
Buckwheat *Fagopyrum esculentum*	Per cup (168g) serving of Buckwheat provides: ▪ Calories: 155 kcal ▪ Carbohydrate: 33.5 g ▪ Fiber: 4.54 g ▪ Sugars: 1.51 g ▪ Fat: 1.04 g ▪ Protein: 5.68 g Manganese, magnesium, phosphorus, niacin (B3), and vitamin B6	Bread, flour, noodles, porridge, rice alternative, soups, and stews	Gluten-free
Kaniwa *Chenopodium pallidicaule*	A quarter-cup (45-gram) serving of kaniwa provides (ESHA NUTRITION DATABASE): ▪ Calories: 160 kcal ▪ Carbohydrate: 30.0 g ▪ Fiber: 3.0 g ▪ Sugars: 0.0 g ▪ Fat: 1.0 g ▪ Protein: 7.0 g Thiamin (B1), phosphorus, iron, manganese, and niacin (B3)	Bread, flour, porridge, soups, stews	Gluten-free

Grain Varieties	Nutritional Profile	Uses	Gluten/ Gluten free
Quinoa *Chenopodium quinoa*	Per cup (185g) serving of cooked quinoa provides: ▪ Calories: 222 kcal ▪ Carbohydrate: 39.4 g ▪ Fiber: 5.18 g ▪ Sugars: 1.61 g ▪ Fat: 3.55 g ▪ Protein: 8.14 g Manganese, magnesium, phosphorus, folate, and copper	Flour, salads, soups, stews	Naturally gluten- free

Table 2. Definitions of the terms used globally related for grain and grain products

Whole grains	Whole grains are grains that consist of the intact, ground, cracked, flaked, or otherwise processed kernel after the removal of inedible parts such as the hull and husk; all anatomical components, including the endosperm, germ, and bran, must be present in the same relative proportions as in the intact kernel to be classified as whole grains.
Refined grains	A refined grain is defined as having undergone a process that removes the bran, germ, and husk of the grain, leaving the endosperm.
Kernel	The kernel in the definition is used for many widely consumed grains, such as wheat, maize, rice, barley, and rye. Other commonly used terms include seed, berry, groats, and simply 'grain'
Bran	In cereal science and technology, and in milling, the bran includes the aleurone layer, whereas in botanical definitions, the aleurone layer is part of the endosperm.
Endosperm	The part of a seed that acts as a food store for the developing plant embryo, usually containing starch, protein, and other nutrients.
Germ	The embryo in a cereal grain or any plant seed
Husk	The outer shell of a seed that encases it and prevents damage from insects or microbes and moisture loss.
Ancient grain	Grains that have largely remained unchanged for hundreds or thousands of years

Pseudocereals	Fruits or seeds of non-grass species that are consumed in a similar way to cereals because their nutritional profiles, preparation, and uses are like cereal grains. The three widely used pseudocereals include amaranth, buckwheat, and quinoa
Cereals	Grains of the *Poaceae* grass family, monocots. May or may not have the natural outer cover called hull that is inedible.
Recombined whole grain flour	The recombination of heat-stabilized separated constituents of germ and bran of milled intact dehusked or dehulled whole grains with starchy endosperm to the relative proportions of the three constituents (bran, germ, and endosperm) as found in the intact grain.
Reconstituted whole grain flour	Process of flour fractionation and recombining with the endosperm fraction to improve the texture and functionality of the flour. It does not necessarily recombine the fractions to obtain relative proportions of bran, germ, and endosperm as present in the natural whole grain.

1.5 Whole grain processing

All grains need processing to make them consumable with improved nutrient bioavailability and storage stability. Processing steps include washing, cleaning, removal of inedible parts (husk/ hulls), dry milling, sifting, wet processing like malting, fermentation, sprouting, etc. The mechanical removal of bran and germ from whole grains through grinding and selective sifting results in *refined grain flours*. Hence, refined grains are obtained by the removal of germ and bran from whole grains. Some examples include white rice (polished rice), refined wheat flour (*maida*), etc. The removal of bran and germ results in the loss of fiber, vitamins, and minerals like magnesium.

Milling processes usually include the recombination of bran and germ fractions to the same endosperm fraction or a different batch, after stabilizing them by heating to reduce rancidity development during storage. Recombined whole grain flours may include endosperm, bran, and germ from different varieties or batches of grain. Sometimes, flour functionality is improved by reconstitution of the fractions to specific proportions depending on the end use. Different processing methods on whole grains have varying effects on their nutritional quality.

Countries like **Denmark and Spain**, do not allow reconstitution but allow recombination for whole grain flours. Refined grains may be enriched or fortified with vitamins like riboflavin, thiamine, niacin, etc., and minerals like iron that are removed during milling. In **Canada**, manufacturers are required to fortify refined wheat flour with folic acid, but there is a loss of fiber and minerals like magnesium that are found in whole grain. The FDA allows the removal of up to 5% of kernel (most of the germ and some bran layers) to control rancidity and increase the shelf-life of whole wheat flour but as per the AACC International definition, only when all parts of the kernel are used in the same relative proportions as existing in the original kernel, the flour can be considered as whole grain.

In some countries, evidence of health benefits of specific grains is necessary, and hence, in **Denmark and Sweden**, only wheat (including spelt), rye, oats, barley, maize, rice, millets, and sorghum are listed as whole grains. As the global definition is on consensus, it allows for the addition of newly developed species of cereal grains through breeding for improving both nutrient content and consumer acceptability and acceptance by relevant authoritative groups.

Whole grains are more nutritious compared to refined grains and products. **Refined grain products** include white flour or refined crackers that are devoid of fiber, vitamins, and antioxidants. Whole grain products like brown rice, oatmeal, popcorn, whole wheat bread, cracked Wheat or Dalia, shelled corn, *Rajgira* flour, whole wheat bran bread, and whole grain pasta offer more nutrients per serving *vis-à-vis* refined grain flour. There are multiple differences between whole grains and refined grains (**Table 3**).

Table 3. Differences between whole grains and refined grains

Whole grains	Refined grains
Contain all three components – bran, germ, and endosperm	Contain mainly endosperm while germ and bran are removed by processing. Sometimes, a few layers of bran are removed and inner layers are retained.
Are rich in fiber, vitamins (especially B vitamins), minerals like magnesium and iron, and antioxidants.	Has mainly starch, some protein, some vitamins and fat. Low in fiber, B vitamins, minerals, and antioxidants
More grainy texture and low shelf life	Have softer texture and longer shelf life.
Not very palatable due to presence of fiber	More convenient and palatable
Fiber improves digestion, helps control blood sugar and spikes, and faster satiety	Fast absorption, glucose spikes shortly after meals and tend to overeat due to low fiber content and low satiety
B vitamins, iron, and magnesium in whole grains support energy, blood health, and muscle function.	Removal of germ and bran results in loss of B vitamins, iron, and magnesium in the refined grains
Consumers eating more whole grains have a lower risk of heart disease, type 2 diabetes, and obesity. This is because whole grains have more fiber, vitamins, and minerals.	More prone to heart disease, type 2 diabetes, and obesity due to lack of fiber, vitamins, and minerals.

1.6 Labeling of whole grain-based products

The FDA has ruled that whole grain foods need to have at least ¾ ounce-equivalent of whole grains. They arrived at this number after dividing the recommended 6 ounce-equivalents of grain foods by 4 eating occasions per day. Chapter 5, section 2.4, of the **FSSAI** gives the standards for whole grain cereals and cereal products, including contaminants, extraneous matter, moisture contents, etc. (5_ Chapter 2_4 (Cereals and Cereal products).pdf). In May 2023, FSSAI had guidelines for the use of terms like brown bread, etc. Whole wheat bread must have at least 75% whole wheat flour, and brown bread should contain at least 50% whole wheat flour.

Products labeled with '***made with whole grain***' indicates that whole grain is an ingredient, although the quantity of whole grain may differ. Products labeled '**whole grain**' would have a higher percentage of whole grains and must meet certain standards as ordained by the certifying organization or governing body. It is important that the ingredient list and nutrition facts panel be checked to know

the actual amount of whole grain present in the product. The mention of '*whole wheat,*' '*whole oats,*' etc. in the beginning of the ingredient list and higher fiber content in the nutritional panel indicate the product is primarily whole grain. Certification by the **Whole Grains Council Stamp** is also a good indicator for customers (**Figure 5**).

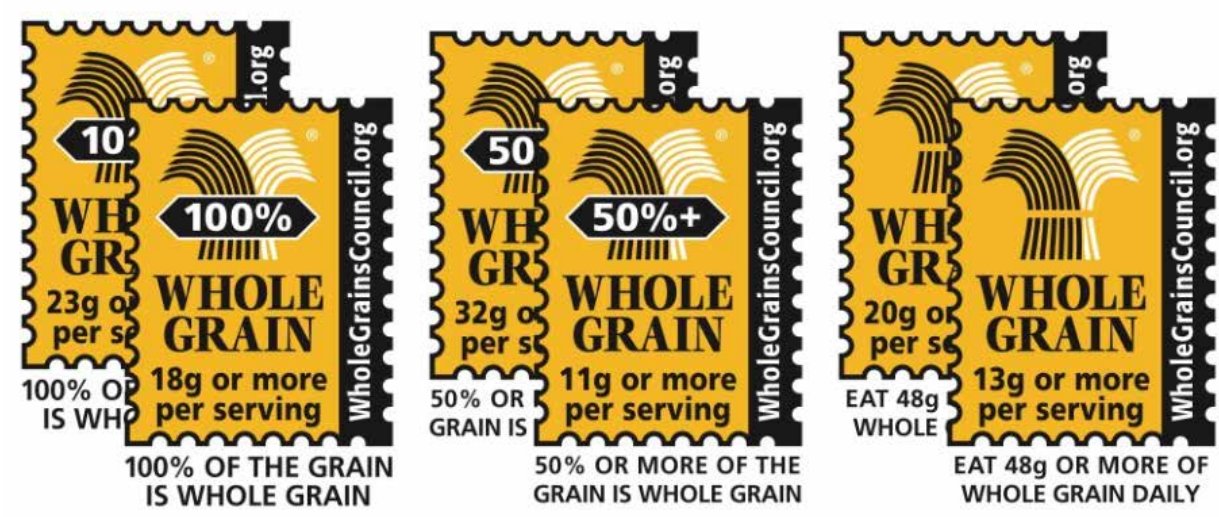

Figure 5. Three different varieties of the Whole Grain Stamp: the 100% Stamp, the 50%+ Stamp, and the Basic Stamp

(Source: https://wholegrainscouncil.org/whole-grain-stamp)

FSSAI-compliant, packaged whole grains (e.g., wheat, rice, and oats) must display the product name, ingredients (descending order), nutritional facts, net weight, FSSAI logo/license number, manufacturer details, batch/lot number, date of packing, and "Best Before" date. Vegetarian/non-vegetarian logos must be present.

1.7 Key Labeling Requirements for Whole Grains

- **Product Identification**: The label must clearly state the product's name, accurately describing its nature (e.g., "Whole Wheat Flour" rather than just "Flour").
- **Nutritional Information**: Mandatory, including energy, protein, fat, and carbohydrates per 100g or per serving.
- **Ingredient Declaration**: Ingredients must be listed in descending order of weight. For single-ingredient products like pure whole grain, this may not be strictly required, but is recommended for transparency.
- **Key Dates:** "Best Before" date and manufacturing/packing date are mandatory.
- **Net Quantity**: Weight must be clearly displayed.
- **FSSAI Logo & License Number**: Mandatory for all food products.
- **Vegetarian Logo**: Green dot inside a square.
- **Origin and Manufacturer**: Name and address of the manufacturer, and country of origin for imported products.
- **Usage Examples & Context**
- **Whole Wheat Packet**: "Whole Wheat Flour" (Name), [Ingredients], Net Wt 1kg, [FSSAI Logo/No.], Best Before 3 months from packaging.

- **Brown Rice Bag**: "Brown Rice" (Name), [Nutritional Info, Batch No., Vegetarian Logo, Manufacturer Details].
- **Ingredients list check:** Harvard Health (https://www.health.harvard.edu/nutrition/in-search-of-healthy-whole-grains-how-to-read-a-whole-grain-nutrition-label) advises ensuring "whole" appears first, e.g., "whole-wheat flour".

Synonyms for Labeling Requirements

- Food Label Regulations
- Package Labeling Standards
- Mandatory Food Labeling Information
- Packaged Food Compliance

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SECTION II

ESTABLISHED HEALTH BENEFITS OF WHOLE GRAINS

Author: **Sesikeran Boindala**

Overview

In **Section II,** we introduce the benefits of whole grains for health, including cardiovascular health, heart disease prevention, obesity, and weight management, and reduced risk of diabetes.

Objectives of Section II

1. To understand the benefits of whole grains in reducing the risk of cardiovascular diseases, diabetes, and obesity
2. To understand the anti-inflammatory properties of whole grains and their benefits in the prevention of cancers
3. To build an evidence base for counselling women and adolescents in communities about the short-term and long-term benefits of consuming whole grains

The world is now challenged with an epidemic of non-communicable/chronic degenerative/ lifestyle-related diseases. While clinical solutions are being applied to mitigate, prevention is the best way of reducing the disease burden. Food and physical activity are the two main pillars of this preventive strategy. The major proportion of the food we consume is constituted by cereals or grains. Whole grains can provide multiple health benefits by virtue of all three grain components being present in them- the bran, germ, and endosperm, offering a dense matrix of dietary fiber, vitamins, protein, and bioactive compounds. Research indicates that consuming 3 servings (48–90g) daily is associated with significant reductions in chronic disease risk. There is growing evidence on the health benefits of whole grains throughout life.

2.1 Cardiovascular Health and Stroke Prevention

Whole grains are consistently linked to lower rates of heart disease and stroke through several mechanisms:

- **Heart Disease Risk**: A meta-analysis of 45 prospective studies found that 90g of whole grains per day (approx. 3 servings) was associated with a 22% lower risk of coronary heart disease.
- **Stroke Reduction**: High intake (approx. 3 servings/day) can reduce stroke risk by 14% to 25%.

- **Cholesterol & Blood Pressure**: Daily consumption of 28–30g can significantly reduce total and Low-Density Lipoproteins (LDL-"bad") cholesterol. Randomized controlled trials (RCTs) show that a whole-grain diet can improve diastolic blood pressure by more than 3-fold compared to refined grains in overweight adults.

There is a consistent, inverse association between dietary whole grains and incident cardiovascular disease in epidemiological cohort studies. Considering this evidence, policy-makers, scientists, and clinicians should redouble efforts to incorporate clear messages on the beneficial effects of whole grains into public health and clinical practice endeavors. The **Nordic Nutrition Committee** recommends a daily intake of at least 90 grams of whole grains. However, the consumption of whole grains is poor globally.

For adults with or without cardiovascular disease (CVD) risk factors, consuming whole grains as opposed to refined grains can improve total cholesterol, low-density lipoprotein cholesterol, hemoglobin A1c, and C-reactive protein.

According to **Aune *et al.*,** around 19%, 22%, 17%, 14%, 51% and 15% reduction in the risk of coronary heart disease, cardiovascular disease, all-cause mortality, and mortality from stroke, diabetes, and cancer, respectively. Low intake of whole grains, in conjunction with other dietary factors, such as high sodium and trans fats in the diet, and low intake of fruits, vegetables, nuts and seeds, omega-3 fatty acids, fiber, polyunsaturated fatty acids, and calcium, contributed to 255 million disability-adjusted life years (DALYs) and 11 million deaths worldwide.

There is limited evidence on the independent association between a particular grain type and disease risk. The reduced risk of diseases like ischemic heart disease has been found to be associated with whole-meal bread intake and similarly, with brown rice.

2.2 Type 2 Diabetes Management

Whole grains improve metabolic health by regulating glucose and insulin levels:

- **Risk Reduction:** High intake is associated with a 21% to 29% lower risk of developing type 2 diabetes (T2D).
- **Glycemic Control:** Soluble fibers, such as beta-glucan, Arabinoxylans (found in whole wheat, oats, and barley), increase intestinal viscosity, which slows the absorption of glucose and helps prevent blood sugar spikes.
- **Recommended Dose:** Evidence suggests that maximal benefit for diabetes prevention occurs at approximately 2–3 servings (60–90g) per day.
- Altogether, the totality of the available evidence supports present dietary recommendations promoting wholegrain foods for the prevention and treatment of T2D.

Results of a systematic review support public health recommendations to replace refined grains with whole grains and suggest that at least two servings of whole grains per day should be consumed to reduce type 2 diabetes risk.

The consumption of whole grain foods can improve the postprandial glucose and insulin homeostasis compared to similar refined foods in healthy subjects.

Whole grain foods improve short-term glycemia and insulinemia, which may improve glycated hemoglobin (HbA1c), a marker of long-term glycemic control. This may partially explain the inverse

association between WG intake and risk of T2D, but further investigations are needed to understand if short-term reductions in glycemia translate to longer-term benefits in reducing the risk of T2D.

2.3 Weight Management and Obesity

Fiber-rich whole grains support weight control by enhancing satiety and influencing energy balance. Recent evidence shows that both the protein and the soluble fiber may trigger a Glucagon-Like Peptide (GLP-1) response, thereby triggering satiety.

- **Body Composition:** Regular intake is linked to lower Body Mass Index (BMI) and reduced central adiposity (belly fat).
- **Satiety**: Whole grains are more filling than refined versions. Research shows that 3 servings daily are linked to less weight gain over 8–13 years (1.27 kg vs 1.64 kg in low consumers).
- **Metabolic Rate**: Substituting whole for refined grains may increase the resting metabolic rate. The consumption of whole grains seems to help burn more calories at rest through various mechanisms.

Consumption of whole grain foods, compared with refined grain foods, significantly impacts subjective appetite and might partly explain the inverse associations between whole grain food intake and risk of overweight, obesity, and weight gain over time.

Recent research has identified different ways in which whole grains protect against major chronic diseases. Oligosaccharides, polysaccharides, and resistant starch in whole grains increase satiety and gut transit, decrease cholesterol, triacylglycerol, sugar, and insulin levels in the blood, and have a prebiotic effect on the bowel; thereby improving large-bowel health, body weight regulation, and decreasing the risk of type 2 diabetes.

Different mechanisms of how whole grains cause weight loss have been postulated, including decreased energy density, increased satiety, slower gastric emptying, slower digestion and absorption, reduced postprandial glycemic response, and gut microbiota modulation. Likewise, whole grains lower LDL cholesterol and thereby protect against clogging of arteries by preventing the formation of clots. Additionally, whole grains like amaranth proteins have lysine, which is not found in many other grains. Buckwheat has antioxidant called rutin that improves circulation and prevents LDL cholesterol from blocking arteries, and oats have beta-glucan fiber that helps lower cholesterol and antioxidant, i.e., avenanthramides, which protect vessels from the damaging effects of LDL cholesterol. Wheat and millets have multiple benefits on health.

2.4 Digestive Health and Cancer Prevention

The fiber and phytochemicals in whole grains play a critical role in gut health:

- **Colorectal Cancer:** Strong evidence exists that whole grains decrease the risk of colorectal cancer by approximately 17% to 21%.
- **Prebiotic Effects:** Whole wheat, corn, and barley act as prebiotics, increasing beneficial gut bacteria like *Bifidobacterium* and *Lactobacillus*.
- **Digestive Function:** Fiber increases fecal bulk and reduces transit time, promotes ease of regular bowel movements, and helps with the problem of constipation and decreases the risk of colorectal Cancers. (*World Cancer Research Fund- evidence-based recommendations*)
- A meta-analysis provides further evidence that whole grain intake was associated with a

reduced risk of digestive tract cancer. These results support the dietary guidelines that increase whole grain intake to reduce the risk of digestive tract cancer.

Yet another meta-analysis of cohort and case-control studies consistently demonstrated that whole grain intake was associated with lower risk of total and site-specific cancer, and yet again supports current dietary recommendations to increase whole grain consumption. By contrast, the relationship between refined grain intake and cancer risk is inconclusive.

2.5 Nutrient Density and Anti-inflammatory Properties

Whole grains contain a variety of "non-energy" nutrients that refined grains lack:

- **Bioactive Compounds:** They are rich in phenolic acids (e.g., ferulic acid), antioxidants, and minerals like magnesium, selenium, and zinc.
- **Chronic Inflammation:** High intake is linked to lower levels of inflammatory markers like C-reactive protein (CRP) and a 30% lower risk of dying from inflammation-related conditions over long periods.

A comprehensive meta-analysis provides further evidence that whole grain intake is associated with a reduced risk of coronary heart disease, cardiovascular disease, and total cancer, and mortality from all causes, respiratory diseases, infectious diseases, diabetes, and all non-cardiovascular, non-cancer causes. These findings support dietary guidelines that recommend increased intake of whole grains to reduce the risk of chronic diseases and premature mortality.

A total of nine randomized trials, including 838 participants, were identified. In a pooled analysis of all studies, consumption of whole grains had an inverse association with inflammatory markers, including C-reactive protein (CRP), Interleukin-6 (IL-6), Tumor necrosis factor-α (TNF-α), and Interleukin-1β (IL-1β). Specific analyses for CRP and IL-6 showed that the whole grain diet was related to a significant decrease in the concentration of CRP. The consumption of whole grains has a moderate effect on the reduction of inflammatory markers.

Summary

Whole grain consumption, even to the extent of 45 to 90 g per day, has a multitude of health and clinical benefits. However, many challenges have been identified that decrease the average consumption of whole grains. These include the dislike toward taste and texture, difficulty in identifying whole grain foods, poor availability, cost, and lastly, the lack of knowledge and demand from the communities. Hence, awareness generation and increased availability are crucial to improve whole grain consumption in communities.

The consumption of whole grains has been associated with a decrease in morbidity and mortality from colorectal cancer, cardiovascular diseases, and type 2 diabetes, and an improved gut microbiome. In addition, an increased consumption of whole grains leads to a reduction in body weight, total cholesterol, systolic blood pressure, and inflammation in the body.

Most of the non-communicable or chronic degenerative diseases that plague the world could be managed and morbidity and mortality reduced significantly by the inclusion of whole grains in a form that nature has provided. It cannot be overemphasized that a healthy diet should also include regular and sufficient physical activity.

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SECTION III

WHOLE GRAIN CONSUMPTION

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Overview

In **section III,** we introduce the figures related to the actual intake of whole grain vs the recommended consumption in the urban and rural areas of India. In addition, we discussed the regional disparities in the consumption of whole grains and the opportunities to promote their consumption using interesting recipes.

Objectives of Section III

1. To explore the intake levels of whole grains among Indians in the rural and urban areas, compared to the recommendations by the Indian Council of Medical Research.
2. To gather evidence on the state-wise differences in the production and consumption of whole grains.
3. To build the rationale of the need to promote the consumption of whole grains in both rural and urban areas.

The prevalence of non-communicable disease (NCDs) is at its all-time high in India, which demands solutions that can be implemented at a community level. As we navigate a complex dietary transition in the country, the over-reliance on staple cereals poses a significant risk to the triple burden of malnutrition—the coexistence of undernutrition, micronutrient deficiencies, and overnutrition-related NCDs. This phenomenon is particularly concerning given that NCDs in India witnessed approximately a 25% increase between 1990 and 2016 (Debnath *et al.*, 2023). My Indian Plate (ICMR, NIN 2024) is a strategic guide designed to optimize macronutrient balance and micronutrient density, along with diet diversity. Despite the well-established health benefits of whole grains, including a reduced risk of cardiovascular disease, certain cancers, and type 2 diabetes, global intake remains suboptimal, a trend also observed within India (Price *et al.*, 2024).

3.1 Daily Recommended Consumption of Whole Grains

Whole grains (WG) have a significant role in managing a healthy lifestyle. Published literature in the recent past emphasises consumption of WG to mitigate the metabolic imbalance in the body and maximize its beneficial impact on gut health. The **Indian Council of Medical Research** (ICMR) Dietary Guidelines 2024 recommend at least 250g of cereals and minimum 50%, 125g as whole grains daily for adults on a 2000 kcal diet. This should contribute 45-55% of the total energy from cereals. It also emphasizes that 30%the cereals should be contributed by millets.

The concept of dietary diversity emphasizes incorporating adequate amounts of other food groups like pulses, legumes, and resistant starch-rich vegetables and fruits, which in turn add to the enhanced quality base of carbohydrates. The addition of plant protein sources and good quality fats through nuts and oilseeds offers a dual benefit of adding low glycaemic index (GI) to the carbohydrate-dense Indian meal. The importance of rationing the quantity of carbohydrates from WG, enhancing quality with dietary fibre to lower GI, and increasing total protein intake has shown a significant impact on the risk of prediabetes and Type 2 diabetes (Anjana *et al.*, 2023)

3.2 Actual Consumption of Whole Grains in India

Current surveillance data reveal a profound deviation from the national guidelines. Despite recommendations for whole grain intake, real-scenario consumption falls short. **The ICMR-NIN report (2021)** on current food group consumption across Indian states reveals significant gaps between suggested intake as per the ICMR-NIN "**My Plate**" and actual WG intake. It examines the distinct trends found in urban versus rural populations while analysing the intake across different regions of India (**Figure 6**).

Figure 6. ICMR - MY plate for Day

The Indian diet remains overwhelmingly staple-centric, particularly in rural regions where the dietary transition toward diversity has stagnated. It was reported that the consumption of cereals (simple and refined) exceeded by 97.1% of the population in rural areas and by 68.8% of the population in

urban areas. In contrast to the recommendation of whole grains, i.e., 45-50% of the total caloric intake, the urban population reported 51.4% consumption of staple cereals, while the rural population showed a staggering 65.2% of total daily energy sourced through cereals (Hemalatha *et al*, 2021). This heavy dependency would suffice the caloric needs, but it comes at the direct expense of poor nutrient density. Furthermore, urban populations are increasingly replacing healthy staples with "other foods" (processed snacks/sweets), further diluting the plate's nutritional quality.

The "**Whole Grains Displacement**" effect is the most critical takeaway from the **ICMR Report (2021).** It is important to develop targeted interventions and formulate informed strategies to encourage increased WG consumption and mitigate the burden of diet-related chronic diseases, especially considering that refined grains like white rice and wheat flour dominate urban consumption patterns (Kane-Potaka *et al.*, 2021). Indeed, the pervasive consumption of refined cereals, such as white rice and breads, often contributes significantly to overall cereal intake in India, potentially reaching up to 76% for rice alone, and this preference for refined options is often linked to improved shelf life (Fardet *et al.*, 2022).

Moreover, this shift towards refined grains, particularly pronounced in urban areas, is directly implicated in the escalating prevalence of type 2 diabetes, with white rice consumption alone significantly increasing risk (Fardet *et al.,* 2022; Mohan *et al.*, 2023). There has been a decrease in the per capita intake of rice, wheat, and coarse grains from 2011-12 to 2022-23 in the rural India (**Figure 7**). The consumption of whole grains was lower in urban India compared to rural India, and has further reduced in the last decade from 2011-12 to 2022-23 (**Figure 8**). Wheat and millets are the staple cereals largely in the North and Western India, compared to different varieties of rice in the South and Eastern India (**Figure 9**).

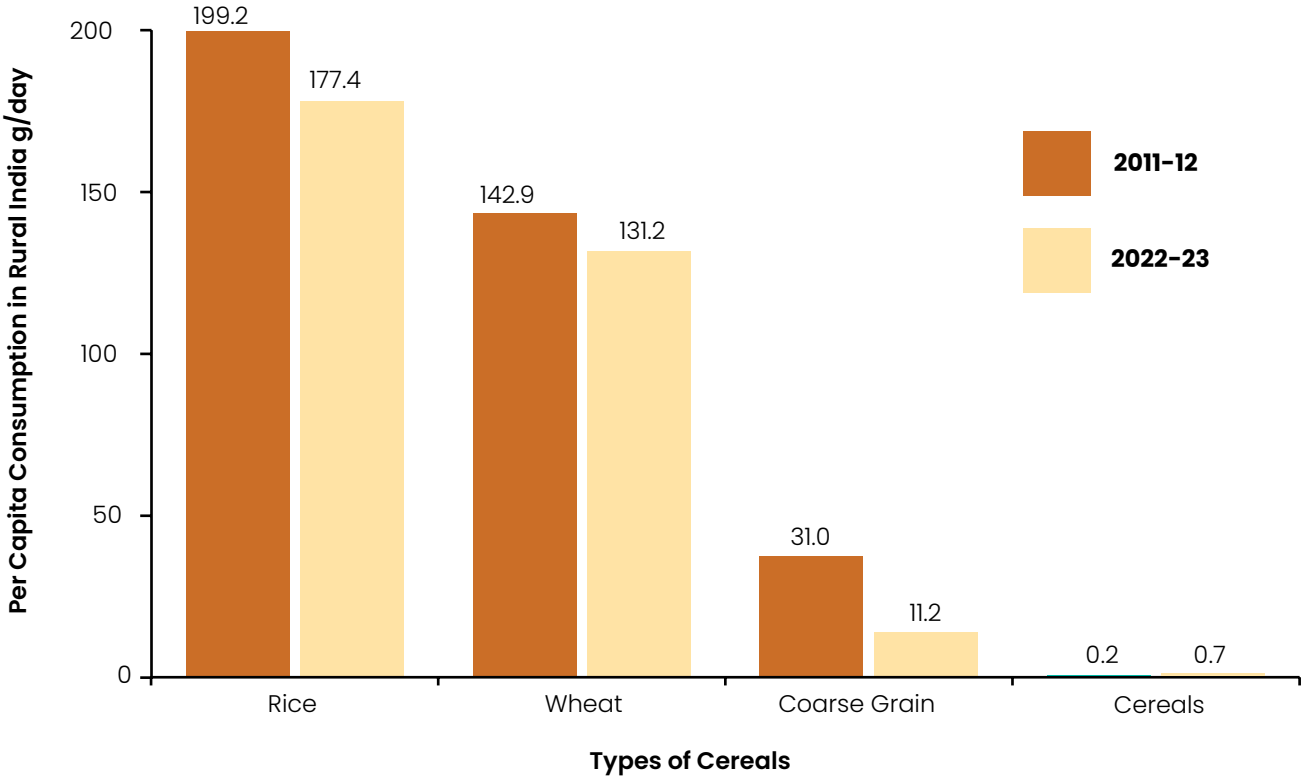

Figure 7. Comparison of the consumption of different cereals in the rural India between 2011-12 and 2022-23 (Insights from the HCES 2022-23)

Abbreviation: *Household Consumer Expenditure Survey*

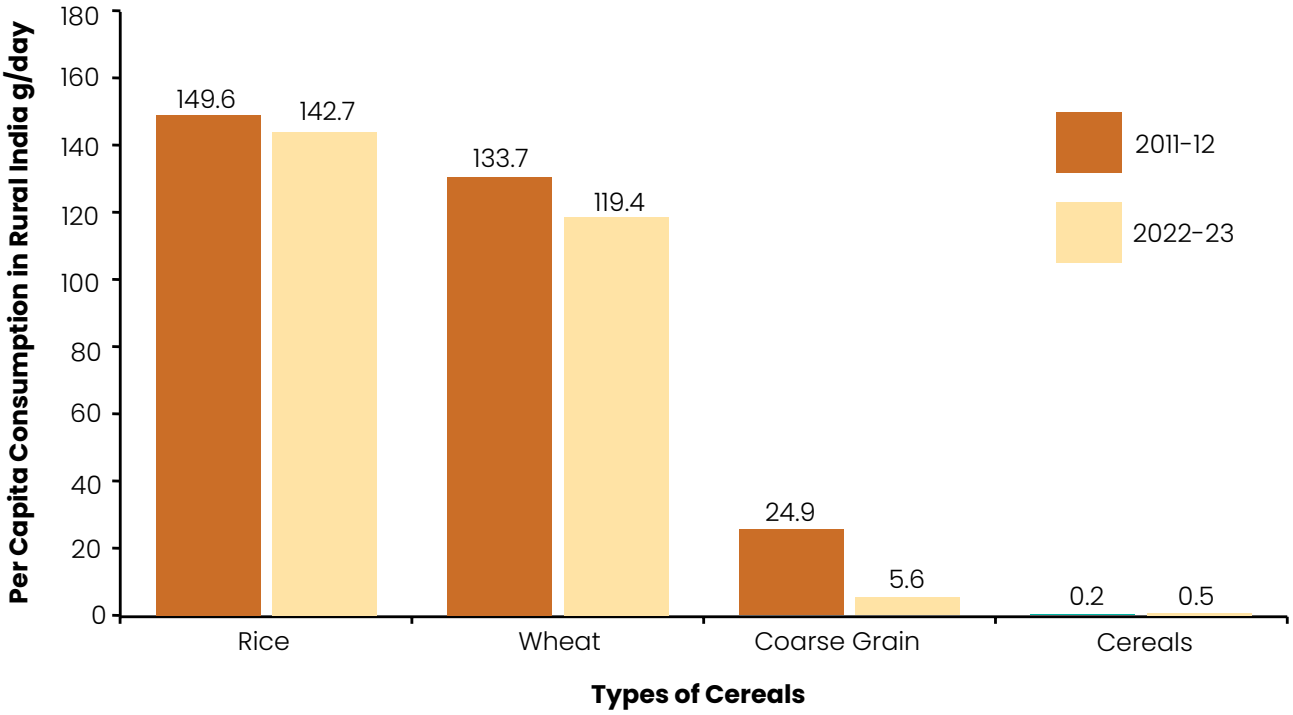

Figure 8. Comparison of the consumption of different cereals between 2011-12 and 2022 in the urban India (Insights from the HCES 2022-23)

Abbreviation: *Household Consumer Expenditure Survey*

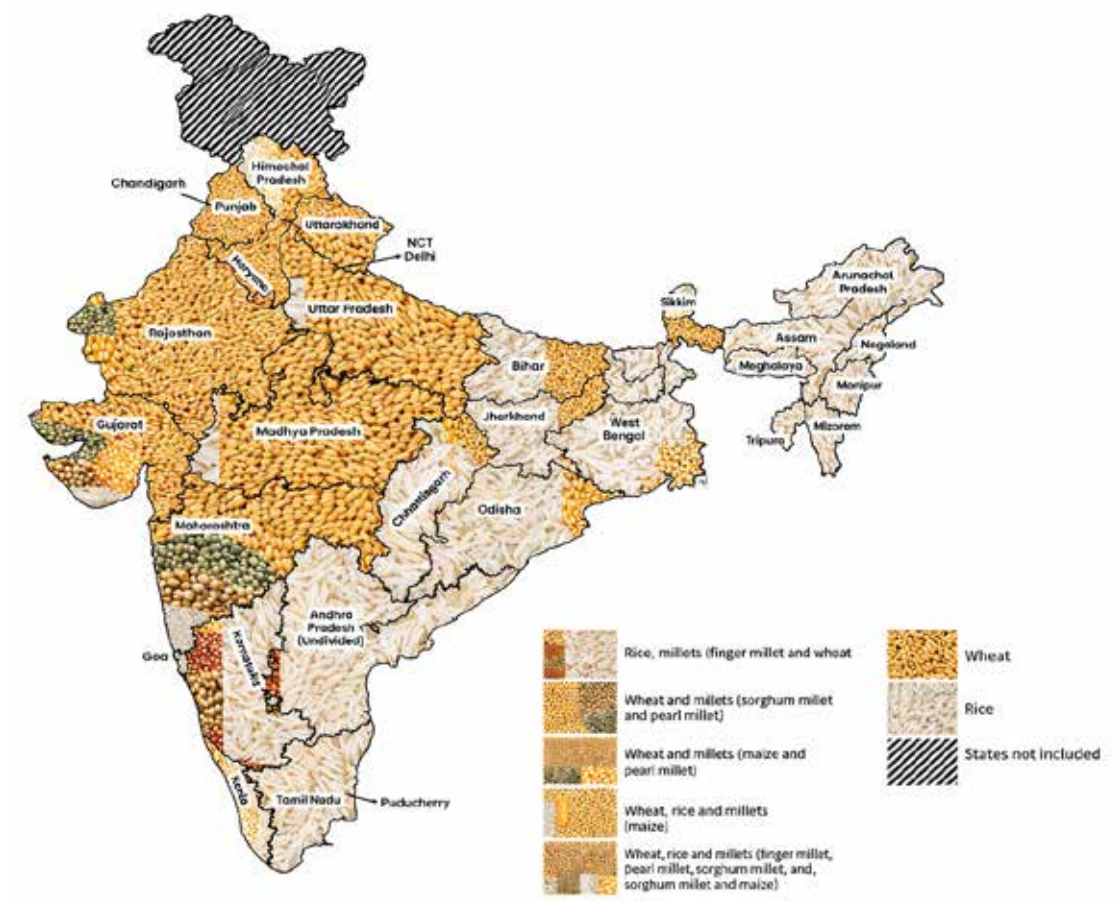

Figure 9. Top three cereal staples reported by the weighted percentage of the study population in each state. (*Anjana et al., 2025***)**

A longitudinal analysis of National Sample Survey Organization (NSSO) and National Nutrition Monitoring Bureau (NNMB) survey data reveals a staggering decline in the per capita consumption of millets. This trend is driven by a lack of an integrated Production-Consumption (PCS) value chain system and a consumer shift toward subsidized fine cereals. (Dayakar Rao *et al.*, 2021). Compared to rice and wheat, the consumption of millets has decreased significantly over the years (**Table 4**).

Table 4. Trend in consumption of Coarse Grains (Dayakar Rao *et al.*, 2021)

Grain Type	Survey Period	Rural Intake (kg/annum)	Urban Intake (kg/annum)
Sorghum (Jowar)	1972–73	19.20	8.50
	2011–12	2.42	1.58
Pearl Millet (Bajra)	1972–73	11.50	4.00
	2011–12	0.97	2.82

3.3 Diversity among States on Whole Grain production

From a policy analyst's perspective, the millet economy is characterized by declining area but improving productivity. India remains the global leader in millet production, contributing 10% to the national food grain basket (Dayakar Rao *et al.,* 2021). India exhibits significant diversity in WG production across states, driven by variations in climate, soil, irrigation, and policy interventions. The WGs, including wheat, rice (brown), and coarse cereals like millets (bajra, jowar, ragi), have **Uttar Pradesh** as their top overall producer, with around 59.3 million tonnes (2023-24) (Pal, 2025). **Punjab and Haryana** excel in wheat yields due to intensive irrigation and **Green Revolution** legacies, producing 32.6 and higher per-hectare outputs, respectively.

Madhya Pradesh follows with 39.8 million tonnes, strong in wheat (20% national share) and pulses (USDA, 2026). **Rajasthan** leads coarse cereals (17% national), especially pearl millet (bajra) at 32% of millet production, suited to arid conditions. **Maharashtra** tops jowar (sorghum) at 34.8%, while **Karnataka** dominates ragi (finger millet) at 16% of coarse cereals. Together, **Rajasthan, Uttar Pradesh, Maharashtra, Karnataka, Gujarat, and Madhya Pradesh** account for 98% of millets (**Table 5**).

Table 5. Production of major and minor millets in India (Dayakar Rao et al., 2021)

Name	Production (MT)	Primary Growing Conditions	Primary States
Pearl Millet (Bajra)	8.6 Mn	Arid/Semi-arid; 200–800mm rain; Temp up to 64°C	Rajasthan, UP, Gujarat
Sorghum (Jowar)	3.47 Mn	Semi-arid tropics; drought-tolerant; C4 pathway	Maharashtra, Karnataka
Finger Millet (Ragi)	1.2 Mn	Wide range of moisture/temp; short 60–90-day cycle	Karnataka, TN, Uttarakhand
Small Millets*	0.33 Mn	Arid/hilly terrains; minimal nutrient requirement	MP, Odisha, Chhattisgarh

**Small Millets include Foxtail, Little, Kodo, Barnyard, Proso, and Brown Top*
***Abbreviations**: MT: Million Tons; MP: Madhya Pradesh; TN: Tamil Nadu; UP: Uttar Pradesh*

However, there exists a disparity in their production across Indian states. The Northern states like **Punjab** and **Haryana** boast of high productivity owing to the canal irrigation, in contrast to the **Southern** and **Eastern** variability that is influenced by monsoons. **Madhya Pradesh** and **Rajasthan** exhibit high production instability, with CVs of 35.9% and 29.6%, stemming from inconsistent cultivated areas. Southern states like **Tamil Nadu** and **Andhra Pradesh** may face challenges but achieve high millet yields (e.g., 2826 kg/ha in Andhra) (USDA,2026).

3.4 Opportunities to Increase the Consumption of Whole Grains among different regions using Regional Recipes

The evolution of the Indian agricultural landscape reflects a systematic transition from a diverse, nutrition-centric production model to a calorie-focused, high-input system. While the Green Revolution of the 1960s achieved the immediate mandate of food security through rice and wheat, it fundamentally marginalized traditional "**Nutri-Cereals**," reducing them to "**orphan crops**". Household consumption was built around diverse grains rich in micronutrients and dietary fibre, with whole grains constituting 40% of the total cultivated grains; however, policies prioritizing high-yielding rice and wheat varieties to fight hunger reduced millets to ~20% of cultivated grains.

Recent initiatives signal a shift to "**nutrition security**", with Millets being formally gazetted as "**Nutri-Cereals**" due to their superior nutrient density (Dayakar Rao *et al.,* 2021). Elevating regional recipes offers a culturally resonant way to boost whole grain consumption across India's diverse regions, bridging the gap highlighted in the **ICMR-NIN report** (2021) between recommended and actual intakes. Promoting WG intake is pivotal for addressing the global rise in NCDs, as WG provide fibre, antioxidants, and micronutrients that mitigate risks of diabetes, cardiovascular disease, and obesity (Aune *et al.,* 2016). **Table 6** details different ways to increase the consumption of WG across India. Different easy-to-make recipes can be made using WG (**Figure 10**).

Table 6. Opportunities to increase the consumption of whole grains in daily routines

State	Traditional Recipes	Elevated Opportunities
Punjab, Haryana	Wheat Paratha	Bajra or Jowar khaki rotis (50:50 blend with wheat flour)
Kerala	Rice/ Kanji	Matta rice (red whole rice)
Tamil Nadu	Upma	*Varagu (kodo millet upma), Adai uttapam*
Assam, Manipur	Rice	*Konidhan* (Foxtail millet rice/ porridge)

Expert-led collaborations between non-governmental organizations (NGOs), industry, and policymakers must prioritize fortified flours, digital recipe tools, and surveyed pilots to propel national intake from 20-30 g/day to the world health organization (WHO) standard of ≥50 g, capitalizing on India's 20+ millet varieties for enduring impact (WHO, 2023).

Easy-to-Make Recipes

Made with Whole Grains

Soft Rotis

Sprouted Grain Dosa

Multigrain Upma

High-Fiber Idlis

Protein-Rich Chilla

High-Protein Cookies

Figure 10. Common recipes from whole grain to increase their consumption

3.5 Processing Impacts on Whole Grain Content of Foods/ Recipes

Processing significantly alters WG content in foods and recipes by affecting its nutrient retention and bioavailability. While **refining** removes bran and germ—rich in fibre, minerals, and phytochemicals—advanced methods like extrusion can enhance functional properties. (Oghbaei & Prakash 2016).

Milling and refining are processes that remove anti-nutritional compounds from husk wheat; however, reduce dietary fibre content, vitamins (like thiamine & riboflavin), minerals (iron & zinc), and phytochemicals (like tannins) while separating bran. In finger millet, sieved flour shows lower protein, fat, ash, and fibre than whole flour. These losses concentrate starch, improving digestibility but diminishing health benefits like antioxidant activity from phenolics and phytic acid.

Another processing technique is **extrusion**, which disrupts cell walls via shear, heat, and moisture, boosting water absorption, solubility, and resistant starch in wheat/millets, aiding gut health via short-chain fatty acids. It lowers glycaemic index, enhances phenolic bioavailability, and reduces oxidation risks (Yi *et al.*, 2022).

At household levels, soaking, germination, and fermentation are commonly practiced. **Germination** reduces antinutrients in legumes/millets (like phytate & tannins), raises mineral bioavailability (iron & zinc), and starch digestibility (by 36-39%). **Fermentation** and **soaking** may leach phenolics/ polyphenols but improve protein digestibility (up to 16.7%) and soluble fibre. **Parboiling** retains more nutrients in rice (Oghbaei & Prakash 2016).

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SECTION IV

BARRIERS AND FACILITATORS IN THE CONSUMPTION OF WHOLE GRAINS

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Overview

In **Section IV**, we introduce the topics related to the consumption of whole grains in India, including their existing patterns, barriers and facilitators, and myths and misconceptions.

Objectives of Session IV

1. To highlight the consumption patterns of whole grains across different age groups, gender, and geographies across India.
2. To highlight barriers and facilitators across different age groups in the consumption of whole grains.
3. To understand the common barriers and construct a sustainable behaviour change model to improve the consumption of whole grains across different stages of the life cycle.

4.1 Consumption Patterns of Whole Grains

The significant role of whole grains (WG) in reducing the risk of non-communicable disease and improving gut health has been well documented in published literature in the recent past. Despite this evidence-based information available, the consumption of WG is still limited in many countries. There is data to show that consumers are emphasizing staples that are refined and devoid of dietary fibre. The FSSAI and the Government of India are emphasizing the reduction in high fat salt and sugar foods. It has also been covered in Dietary Guidelines for Indians (ICMR-NIN, 2024).

The recommended intake of **WG** globally ranges from 48 g/d in the United States to up to 90 g/d for men in Sweden and Norway. In India, the recommendation of WG cereal intake, including millets as per the Dietary guidelines 2024 for adults, is 250 g per day on a 2000 Kcal diet. However, actual WG intakes are below these recommendations in almost all countries worldwide. In children and adolescents, data from nationally representative surveys show that average intakes (expressed in amounts of WG ingredients) range from approximately 2 g/day in Malaysia and Italy to 23 g/day in Ireland, and up to 58 g/day in Denmark. In adults, they range between about 4 g/day in Italy and 28 g/day in Ireland, and reach 58 g/day in Denmark. In the USA, the average intake of WG in the overall adult population is around 15 g/day.

A recent survey in India revealed that only 2% of the surveyed millennials were aware of all aspects of WG. Daily WG consumption in millennials was less than 10% (42 g/day) compared to the total grain consumption (432g/day) across food categories. Nutritionists and dieticians showed better responses than millennials. Around 50% nutritionists and dieticians consume oats for breakfast. Therefore, there seems to be a need to increase awareness regarding WG consumption in both children and adults, and to understand what factors may influence WG intakes in these populations. Existing literature indicates the gaps in knowledge, attitudes, and practices relating to the WG consumption.

4.2 Barriers and facilitators of whole grains consumption

A recent narrative review summarized the main barriers and facilitators of the WG consumption in children and adults, as identified from the data collected in the frame of the review. Various factors exist across different age groups that facilitate/hinder the consumption of WG (**Figure 11**).

	Kids		Adults		
	Children	**Adolescents**	**Young**	**Middle-aged**	**Older**
Barriers (+)	Disklike taste/ texture	Poor availability of FCWG	Disklike taste/ texture	Cost of FCWG	Cost of FCWG
	Poor availability of FCWG	Disklike/ texture	Cost of FCWG	Dislike taste/ texture	Difficult to identify FCWG
	Lack of appeal (appearance/ pack/marketing)	Time-consuming to prepare/eat	Difficult to identify FCWG	Difficult to identify FCWG	Disklike taste/ texture
	Difficult to identify FCWG	Lack of appeal (appearance/ pack/ marketing)	Poor availability of FCWG	Lack of appeal (appearance/ pack/ marketing)	Poor availability of FCWG
Barriers (–)	Lack of knowledge on nutrition and health benefits	Cost of FCWG	Lack of knowledge on nutrition and health benefits	Dietary habits and other family members (children)	Chewing difficulties (institutions)
Facilitators (+)	↗ Sensory appeal	↗ Availability of FCWG	↗ Sensory appeal	↗ Sensory appeal	↗ Ability to identify FCWG
	Incorporate WG in usual and well-liked products	Presence/ liking of taste/texture	Availability of FCWG	Availability of FCWG	Sensory appeal
	Familiarization to FCWG	↗ Sensory appeal	Familiarization to FCWG	Familiarization to FCWG	↗ Availability of FCWG
	Presence/ liking of taste/ texture	Incorporate WG in usual and well-liked products	Presence/ liking of taste/ texture	Clear labelling of WG on packs	Presence/ liking of taste/ texture
Facilitators (–)	↗ Availability of FCWG	↗ Variety of FCWG; ↗ Ability to identify FCWG	↗ Ability to identify FCWG	Education vs FCWG cooking / preparation	Education vs FCWG cooking / preparation

Figure 11. A matrix of barriers and facilitators in the consumption of whole grains

Abbreviations: *FCWG: Foods containing Whole Grains; WG: Whole Grains*

In **Figure 11**, the factors are presented in the decreasing order of their possible importance (from + to -), for each age group separately, on the basis identified from the data collected in the frame of the current review. Factors are presented in decreasing order of their possible importance (from + to -), for each age group separately, based on the of the number of studies that have concluded that the corresponding factor was a barrier or several studies that have concluded that the corresponding factor was a barrier or a facilitator WG or FCWG (Foods Containing WG).

The most important barriers and perceptions in incorporating **brown rice**, which is also considered a dietary fibre-dense option of whole grains, especially in India, and has a low glycaemic index, include appearance of the grain, cooking quality, and mouthfeel.

Millets have been in focus as whole grains in India and globally, especially with the Government of India declaring the Year of (Shree Anna) Millets in 2023. Despite the impetus given to the cultivation, processing, and startups of millets in India, the key consumption barriers include limited knowledge of culinary skills to cook millets as compared to modern convenience foods, the availability, accessibility, affordability, and cost.

The perceptions of nutrition science professionals were also captured in the recent study. The results indicated that WG foods were perceived positively and are regularly promoted in dietetic practices. The dietitians tended not to consider WG breads and ready-to-eat breakfast cereals as excessively processed, although most generally agreed with the classification system based on the extent of processing. There is a need to incorporate NOVA and concepts of UPFs in the anomalies regarding the categorisation of whole-grain choices and optimum intakes.

The relationship between food tastes, meal preferences, and eating habits has been studied extensively in recent years; however, research on gender differences in these fields still needs to be addressed. There is no gender specific data in relation to whole grain intake.

4.3 Important Barriers to Whole Grain Consumption in India

1. **Sensory and Palatability Issues**
   - **Texture and Taste**: Many consumers perceive WG (like brown rice or ragi) as rough, hard, or having an undesirable taste.
   - **Appearance**: Refined grains are often seen as “cleaner” or “superior” compared to the rustic appearance of WG.
2. Convenience and Time Constraints (Major Urban Barrier):
   - **Preparation Time**: WG require longer soaking and cooking times, which is a significant deterrent for busy urban professionals and households.
   - **Limited Ready-to-Eat (RTE) Options**: There is limited access to tasty WG RTE products, which are nutrient-dense and low GI compared to processed, refined alternatives.
3. **Knowledge and Awareness Gaps**
   - **Misidentification**: Consumers often struggle to identify true WG products, as many products are falsely marketed as “healthy” or “whole wheat,” but are blends with a minimal percentage of WG.
   - **Low Awareness**: In a study of urban Indian millennials, only 2% were aware of all aspects of WG.

4. **Cost and Accessibility**
   - » **High Price**: Processed WG products (e.g., specialized atta, healthy biscuits, breakfast options, snacks) are often perceived as more expensive than refined counterparts.
   - » **Availability:** While raw grains are available, processed low GI WG options are often missing in local, smaller stores.
5. **Cultural and Familial Factors**
   - » **Habitual Consumption:** Deeply ingrained habits of eating white rice or polished flour make it hard to shift to healthier alternatives.
   - » **Family Preference**: Children and family members may be wary of the taste of whole grains, leading to a "separate cooking" hurdle.

4.4 STEPS to promote the consumption of Whole Grains

The main methods to facilitate WG intakes in both adults and children seem to be:

i. To increase the **availability and the variety of foods** containing WG
ii. To improve their **sensory appeal**
iii. To reduce **their purchasing cost**
iv. To use a **familiarization period** to introduce them to consumers (with a gradual increase in consumed amounts and repeated exposure), and
v. To **improve communication and labelling** to enhance consumers' ability to identify products with WG.

These strategies may be used to improve the effectiveness of programs aiming at promoting WG consumption, with a further emphasis on the need to apply them over a long period of time. The settings of schools, colleges, organizations with in-house food availability are ideal to begin with.

Additionally, some other suggestions include:

1. **Innovation in Processing**: Developing WG products that mimic the low glycaemic property and sensory appeal (taste/texture) of refined grains. Innovate intact brown rice and WG cereal-based value-added products, which are age-specific and context-specific.
2. **Education and Labelling**: Clearer labelling of "*whole*" vs. "*refined*" and awareness campaigns about what constitutes a WG.
3. **Gradual Introduction**: Using a familiarization period to introduce WG slowly into the diet to build preference.
4. **Strengthening the ecosystem** of local millets and millet-based products with nutrient density and low glycaemic property after processing to be available at affordable prices. Making millets and brown rice, fortified rice available in the Public Distribution System (PDS) to reach the vulnerable groups.
5. **Food-to-Food Fortification** can also be of value using a combination of WG, millets with legumes, dals, nuts, and oilseeds to improve the nutrient density.

4.5 Myths and misconceptions about Whole Grains

Myth: All brown bread is whole grain.

Fact: Many brown bread products are merely white bread, with added colour or molasses. Always check for "**100% whole wheat**" or "**100% whole grain**" as the first ingredient.

Myth: Whole grains make you fat/are too high in calories.

Fact: The high fibre content in whole grains promotes satiety (feeling full), which aids in weight management.

Myth: "Multigrain" is the same as "whole grain."

Fact: Multigrain simply means multiple types of grain were used, but they may all be refined. "Whole grain" is the key term to look for. Multigrain when added in adequate amounts for various whole grains provide goodness of all grains.

Myth: All grains are bad for you/contain toxins.

Fact: Whole grains are safe, nutritious, and recommended by health experts. They reduce the risk of type 2 diabetes, stroke, and heart disease.

Myth: You should avoid them if you want to eat gluten-free.

Fact: While some grains contain gluten (wheat, barley, rye), many whole grains are naturally gluten-free (quinoa, brown rice, millet, buckwheat).

Myth: Whole grains taste bad.

Fact: Whole grains offer a diverse, nutty flavour and a better texture than refined, processed alternatives.

Myth: You do not need them if you eat vegetables.

Fact: While fruits and vegetables are essential, whole grains provide specific nutrients and sustained energy (complex carbohydrates) that vegetables do not.

Myth: They are too processed.

Fact: True whole grains contain the entire grain kernel—the bran, germ, and endosperm—retaining their natural nutrients, unlike refined grains, which are only starch (endosperm). Dietary guidelines recommend a daily consumption of 125g of whole grains (for simpler understanding 4 rotis/dosas of whole grains flours like wheat, ragi, bajra, and other millets).

Myth: Whole grains cause bloating and distension.

Fact: Yes, whole grains may cause bloating because of FODMAP carbohydrates (fermentable oligosaccharides, disaccharides, monosaccharides, and polyols) and insoluble fiber, which are fermented by gut bacteria. However, it is temporary and manageable by drinking plenty of water, soaking or fermenting grains, cooking grains well, and combining them with probiotic foods. A slow and steady inclusion of whole grains in balanced diets earlier devoid of them helps body get adjusted over a period and help support metabolic health. Specific processing steps like soaking, boiling, and draining the water can reduce the FODMAP Content of grains and reduce gas formation or flatulence and help individuals with discomfort after eating whole grains.

Myth: Whole Grains Cause Inflammation

Fact: Whole grains are part of the solution, not the problem, when it comes to inflammation. Research increasingly shows that systemic inflammation may fuel many diseases, from allergies to

heart di a slow asease to cancer. In a recent clinical trial, researchers at the University of Nebraska showed that eating a cup of whole grain barley or brown rice (or a combination of the two) for as little as four weeks can increase the "good" bacteria in your gut that fight inflammation. In another randomized controlled trial, this time in Iran, overweight girls were divided into two groups, one eating mostly refined grains and one eating mostly whole grains. There was a significant reduction in inflammation markers among those eating whole grains.

Myth: All grains make your blood sugar spike.

Fact: The Glycaemic Index rates how quickly carbohydrate foods are converted into glucose. Whole grain foods have a low GI score (55 or less). All intact whole grains have a very low GI score: whole grain barley has a GI of about 25, buckwheat about 45, and brown rice about 48. Pasta has a low GI score, with whole grain spaghetti rating about 37, and even "white" pasta coming in at 42-45. That is because the starch structure of wheat used for pasta (durum wheat) causes it to be digested much more slowly. There is a need to educate people about Glycaemic Index (GI) and Glycaemic Load (GL). Whole grains consumed with Portion Control in a meal along with High protein and Vegetables can give the maximal benefit in stabilizing blood sugar levels.

Myth: White bread is just as healthy as whole grain bread.

Fact: Refining whole wheat flour to make white flour greatly decreases a wide range of nutrients, including fibre, protein, vitamin E, vitamin B6, potassium, and magnesium. White breads have a higher GI than intact whole grains. Whole grain breads (GI of 69), on an average, typically have a more gentle impact on your blood sugar than white breads (GI of 75). Additionally, whole grain breads include all those extra nutrients.

Myth: Is *Chakki* atta better than Packaged atta?

Fact: A standard packaged whole wheat atta is a good option to consider as it safeguards the quality of ingredients with packaging for quality parameters and safe and hygienic usage and many time is carefully designed for optimal level of protein, fibre, and micronutrients....fortified or inherent.

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SECTION V

RECOMMENDATIONS AND WAY FORWARD

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Overview

In **section V,** we come up with key suggestions, recommendations, and way forward to promote the consumption of whole grain in rural and urban communities of India.

Objectives

1. To identify simple, evidence-based health education programs that can promote the consumption of whole grains
2. To suggest key recommendations for the policy makers, academicians, civil society organizations, and industry specialists to innovate, create, and implement whole grain promotion products or behavior change models

5.1 Highlight key benefits and recipes of Whole Grains

India is the second largest producer of cereals after China, constituting 10.53% of the total world's share of cereal production. Cereals have also been explored as a **vehicle of fortification**, such as with B-complex vitamins, vitamin C, vitamin D, iron, Vitamin E, zinc, and beta-carotene. Furthermore, **whole grain proteins** can alter the composition of the gut microbiota, thereby promote the growth of helpful bacteria, and reduce that of harmful bacteria. The presence of **unsaturated and saturated fatty acids** like linoleic, oleic, and palmitic acids makes whole grains a package of multiple nutrients. Both **essential and non-essential amino acids**, like threonine, valine, leucine, tryptophan, glutamate, serine, arginine, cysteine, etc., are present in good quantities in whole grains.

This has also been emphasized to remove stigma among the public about considering all carbohydrate sources as bad. Though presently Indian meals are rich in refined grains and poor in proteins, traditional Indian meals and recipes were based on whole-grain carbohydrates, including amaranth, barley, millets, and other ancient grains. Need to shift both the **macronutrient composition** (inclusion of more proteins and less carbohydrates) and **macronutrient quality** (better carbohydrates like whole grains) has been highlighted. It is imperative to note that wheat-based and millet-based formulations have lower glycemic indices than rice-based formulations.

Some states like **Tamil Nadu** have the highest consumption of refined cereals, which is nearly 51% of the energy in the daily intake, and the lowest milled whole grain consumption (<10%). Furthermore, it has also been reported that carbohydrates, including whole grains, might increase the risk of diabetes, obesity, and pre-diabetes by 11-29%. Hence, it is paramount to consider that people should **reduce the overall consumption of carbohydrates** and **the maximum proportion of the carbohydrates should come from milled whole grains and not refined cereals.** Some of the key reasons in other countries why the consumption of whole grains has been lower than the standard recommendations include their tastes, cost, lack of awareness about their benefits, etc. There are regional variations in the form in which whole grains are consumed in India. While **bajra** is eaten as *kichri* and *crisp rotis*, **corns** are eaten as *flour or popcorn*, **ragi** is eaten as flat breads, dosas, and roti across India.

Whole grains form one of the eight food groups suggested by the **EAT-Lancet commission** as a part of the 2500-kcal reference diet. Though one-third (811 kcal) of the total calorie intake has been advised to come from cereals by the **EAT-Lancet commission**, around half (47%) comes from whole grains. The proportion of calorie share of cereals escalates up to 70% in the rural poor households.

5.2 Evidence-based Health Education Programs

Community-or school-based programs are critical to be implemented to educate kids and communities about the importance of whole-grain and a healthy dietary pattern. **Participatory school-based programs** help students learn to identify, select, and consume whole-grain foods. Furthermore, it has been suggested to make all whole-grain and their products tax-exempt to promote their consumption. Standardizing the labeling of whole grains products will help the population make informed choices to purchase them. The dietary recommendations should specify clearly the amount and forms in which the whole grains should be consumed.

Different **communication campaigns**, either using mid-media or mass media approaches, should be run to generate awareness in the public. Most available evidence currently is in the form of observational data; hence, we need to perform more interventional studies or use data from longitudinal cohorts to assess the effectiveness of the intervention.

Some of the key initiatives in India include the **Odisha Millet Mission (OMM),** which is a farm-to-plate community model. The program aims at reviving millet cultivation and consumption in tribal/rainfed areas through supporting self-help groups, farmer collectives, local festivals, and community recipe demos. The Food Safety and Standards Authority of India (FSSAI) initiated the **Eat Right India program**, which is a community campaign in schools & cities. Besides, the government of India observed 2023 as the **International Year of Millets 2023**.

Anitha S, *et al.*, demonstrated a high acceptability of millet-based meals, such as *finger millet idli, little and pearl millet bisi belle bath*, and *upma i*n an intervention study. The authors suggested introducing millets in **school feeding programs** to improve the nutritional outcomes of children. Furthermore, the study showed a statistically significant improvement in stunting and the body mass index among children within a 3-month intervention period. This white paper highlights the importance of engaging with women and men in the communities to make them aware of the benefits of whole grains and ensure a daily consumption of 120-130g.

MacNab *et al.*, assessed the effectiveness of a whole grain nutritional education program for adults aged >60 years. The education program involved discussions, participation in hands-on activities,

and taste testing of the whole-grain-based products. The intervention showed a statistically significant increase in the knowledge scores, positive intention to eat whole grain foods, and the actual consumption**. Leak *et al.*** encouraged the intake of whole grains by pairing them up with the liked fruits and vegetables and selling them as whole grain snacks. A significant liking and willingness to purchase whole grain snack packs was noted among youth between 10-18 years old. at the New York City corner.

Likewise, the **Malaysian Great-Child Trial** was based on a multi-component whole grain intervention that targeted behavioral, personal, and environmental factors. This quasi-experimental study design assessed the change in knowledge, attitude, and practices of whole grain consumption among children (9-11 years) who were overweight or obese. Based on the Social Cognitive Theory (SCT) principles, the intervention involved a 6 months follow-up, and found a significant difference in the KAP score among the intervention group compared to the control group.

Institute for Global Development, in partnership with ITC Limited, piloted a community-based intervention in two districts of Tamil Nadu, entitled *"**Aarogyam Aanandam Aashirvadam.**'* The initiative uses behavior change communication, participatory methods, and local food systems strengthening to make whole grains a staple for families across targeted geographies. The project adopted the key four approaches:

1. Community-based events like street plays and camps in the communities to disseminate messages to women and men
2. Recipe demonstration and nutritional workshops for different whole wheat-based recipes by the nutritionists
3. Stakeholder meeting on improving whole wheat/grains use in villages in various forms and promoting their growth and cultivation
4. Educational sessions with beneficiaries on importance of whole wheat/grains

5.3 Key recommendations

1. Use a combination of whole grains, grams, and greens. Include jaggery or sugar and cooking oils to bridge the calorie or energy gap.
2. Consume at least half of all grains as whole grains, and have at least 3 servings of whole grains per day.
3. Increase whole-grain intake by replacing refined grains with whole grains.
4. Use whole grains and minimally processed grains. Brown rice, barley, oats, fiber-rich whole wheat, Millets, grain pulses.
5. Different whole grain-based products that can be included in diet include whole wheat flour, semolina, broken wheat, bajra (whole), bajra and jowar flour, popcorn, corn starch, and ragi (**Figure 12**).
6. Innovation through Food-to-Food Fortification with Whole grains to improve nutrient density.
7. Customizing ready to eat products using whole grains to age specific and region specific choices for better acceptability.
8. Develop Indian Database on the Glycemic Index and Glycemic load of whole grain cereal-based products.
9. Further research is warranted to understand the acceptability and affordability of home-based and commercialized foods containing whole grains.

10. Clinical studies should be undertaken to assess the precise effect of whole-grain-based products on different body parameters, including HbA1C, post-prandial blood glucose, C-reactive proteins, body weight, insulin resistance, gut microbiome, blood pressure, and lipid (cholesterol, triglyceride, etc.) and liver profile.
11. Co-create and design recipes and approaches to promote the consumption of whole grains in both rural and urban communities with key stakeholders, like women, frontline workers, and nutritionists.
12. Fortify whole grain flour and products with micronutrients, which are lost during processing techniques.
13. Large-scale community-based campaigns to educate people about label decoding of whole-grain-based products, as suggested by FSSAI.

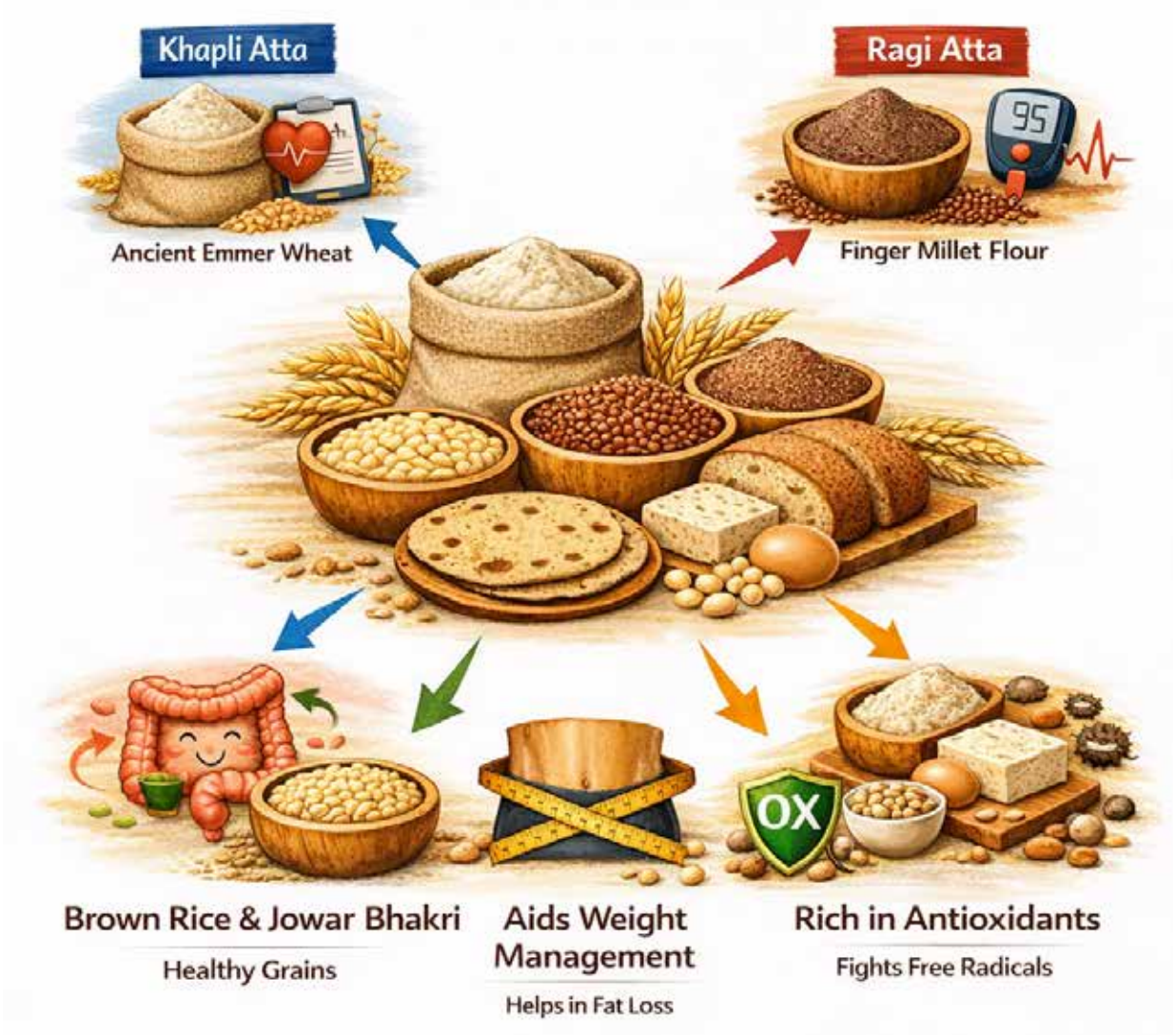

Figure 12. Fortified Whole-Grain-based and sugar-controlled wheat flour

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