Primary Research

Enriching Chakki Atta (Stone Ground Whole Wheat Flour) with high fiber content and its outcomes

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Abstract

This research explores the enhancement of Chakki Atta (Stone Ground Whole Wheat Flour) by increasing its fiber content through various methods. The study focuses on the addition of wheat bran to the flour and evaluates the impact on fiber content, texture, and consumer acceptance. The findings indicate that incorporating 3% bran into Chakki Atta significantly boosts its fiber content while maintaining favorable sensory qualities. Higher percentages of bran result in a decline in texture and taste. The research underscores the importance of food fortification in addressing micronutrient deficiencies in Pakistan, particularly among women and children. It also highlights the role of private-sector food producers and the need for robust quality control measures. The study concludes that fortifying Chakki Atta with bran is an effective strategy to improve its nutritional profile, with 3% being the optimal percentage for consumer acceptance.

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Food fortification is a proven, safe, and cost-effective method for preventing micronutrient deficiencies and has been widely used in developed countries for over a century.

Undernutrition and micronutrient deficiencies in Pakistan

To provide context for discussing potential food fortification opportunities in Pakistan, we have briefly outlined the trends and current status of key indicators related to undernutrition and micronutrient deficiencies in women and children. The focus is on deficiencies of Iron, Vitamin A, Iodine, Zinc, and Vitamin D, all of which are closely linked to food fortification.

For children under 5 years, common indicators of malnutrition include stunting (low length/height-for-age), wasting (low weight-for-height), and underweight (low weight-for-age).

Tables 1 and 2 present the trends in these indicators over time in Pakistan, and by urban/rural location and province in 2011.

Table 1. Prevalence of malnutrition in children <5 years, 1965-2011

	1965	1977	1985-7	1990-4	2001	2011
Stunted	49.0%	43.3%	41.8%	36.3%	41.6%	43.7%
Wasted	11.0%	8.6%	10.8%	11.8%	14.9%	15.1%
Underweight	-	53.3%	47.9%	40.1%	31.5%	31.5%

Table 2. Prevalence of malnutrition in children <5 years by province and age, 2011

	Pakistan		Punjab	Sindh	KP	Balochistan
	Urban	**Rural**				
Stunted	36.9%	46.3%	39.2%	49.8%	47.8%	52.2%
Wasted	12.7%	16.1%	13.7%	17.5%	17.3%	16.1%
Underweight	26.6%	33.3%	29.8%	40.5%	24.1%	39.6%
	0-6m	**7-12m**	**13-24m**	**25-36m**	**37-48m**	**49-60m**
Stunted	23.8%	30.3%	47.9%	54.7%	52.3%	38.4%
Wasted	26.3%	23.2%	15.8%	14.5%	11.2%	13.9%
Underweight	29.0%	33.3%	32.1%	35.3%	28.6%	27.1%

Both stunting and wasting have risen over the past decade. Currently, around 44% of children are stunted, and approximately 15% are wasted, which are considered very high levels of malnutrition compared to global standards.

Commissioned by the UK Department for International Development (DFID) Pakistan, this scoping study was conducted by an international team of consultants to explore and compare potential food fortification strategies in Pakistan. The study focused on three main areas: the regulatory framework for food fortification, the role of the private sector, and potential agricultural solutions. The study was conducted in three phases: Phase 1 involved a descriptive analysis to map the current state of food fortification, Phase 2 evaluated selected fortification options based on their potential impact and feasibility, and Phase 3 included an economic analysis of these options

The role of the private sector

Mandatory fortification of staple foods requires private-sector food producers to modify their manufacturing and quality control processes, which demands financial and technical resources. In Pakistan's privately owned wheat flour and edible oil/ghee industries, the main challenges to implementing fortification are concentrated in two key areas at the manufacturing level:

- Procurement of additional production inputs, such as:
    - Fortification premixes
    - Capital equipment

- Establishing robust internal quality control, which includes:
    - Equipment calibration and proper storage and dispensing of premixes
    - Internal capacity for sample testing
    - External independent laboratory analyses

Several potential actions were identified to overcome these barriers, such as conducting detailed supply chain analyses, supporting the procurement of premixes, equipment, and lab consumables through subsidies or revolving funds, and investing in private-sector laboratories.

Beyond fortification in the wheat flour and edible oil/ghee sectors, other private-sector areas where fortification could be implemented include:

- Wheat flour fortification by small-scale Chakki millers

- Fortification of commercial complementary foods for infants and young children

Fortification can be implemented at three levels: mass or universal, targeted, and household. Mass or universal fortification, which should ideally be legislated and mandatory for industries, aims to produce fortified foods that are consumed widely by the general population (such as iodized salt and wheat flour fortified with iron and folate). This method is the most cost-effective nutrition strategy, especially when conducted by medium- to large-scale industries. Targeted fortification (such as nutrient-enhanced complementary foods for children aged 6-24 months) focuses on specific vulnerable groups, including infants, young children, women of reproductive age, and those in emergencies, whose diets are lacking essential nutrients. It is particularly effective in low-resource settings where family diets are deficient in animal-based foods, which are crucial for meeting the nutritional needs of young children.

Currently, there is no provincial legislation requiring the mandatory fortification of wheat flour. However, a national standard has been established that differentiates fortified flour from regular flour by the inclusion of one or more vitamins or minerals, such as calcium carbonate, iron, thiamine, riboflavin, and niacin. Folic acid is not included in the list. While a permissible range for adding calcium carbonate is provided, there are no specific guidelines regarding the levels of other fortifications**.**

While the Provincial Food Department does not have a legal role in regulating food quality and safety, it plays a key role in monitoring the quality of wheat flour. Its main responsibility is overseeing government procurement and storage of wheat, then distributing it to industrial flour millers through a quota system. The Food Department also uses its standard operating procedures and network of specialized laboratories to collect and analyze grain and flour samples. This includes profiling grain characteristics during procurement and testing flour to ensure it meets standards, especially concerning moisture content.

Pakistan Standards and Quality Control Authority (PSQCA) is responsible for inspecting and analyzing samples to ensure compliance with mandatory standards. While most of the 15,000 national standards currently in place are voluntary, those specified in legislation must be followed.

Other public-sector institutions and agencies also play a role in supporting the monitoring and enforcement of food quality and safety in Pakistan, including the following:

- ***Pakistan Council for Scientific and Industrial Research:*** *While its primary role is to provide scientific support to industries, it also serves as a key institution for investigating and resolving disputes concerning the quality and authenticity of raw and finished food products and pharmaceuticals.*

- ***National Institute of Health:*** *This institute is involved in public health activities such as diagnostic services, research, and the production of biological vaccines. It also functions as a Reference Laboratory for testing the iron and folic acid content in wheat flour samples and as a Public Analyst Laboratory for the Islamabad Capital Territory. The laboratory has previously conducted food analysis for vitamin A content using the traditional titration method.*

- ***National Institute of Food Science and Technology, University of Agriculture:*** *This institution acts as an Accredited Focal Laboratory for addressing issues related to food purity, following the Hazard Analysis and Critical Control Points (HACCP) approach to food safety and other national standards.*

- ***Other university departments of food sciences and dietetics, such as those at the University of Karachi, have some capacity for analyzing fortified food samples, though these resources have not been utilized at any significant scale for this purpose.***

According to the 2006 World Health Organization (WHO)/Food and Agriculture Organization (FAO) guidelines on food fortification, an effective regulatory monitoring system for food fortification requires internal, external, and commercial monitoring, supported by suitable legislation. Efforts to mandate the fortification of wheat flour and salt are currently underway in Punjab. Additionally, a framework for internal, external, and commercial monitoring is already established in all provinces, along with judicial enforcement mechanisms. However, the existing limitations within each regulatory area impact both the

current assurance of food quality and safety and the successful implementation of future food fortification programs.

The National Wheat Flour Fortification Programme (NWFFP) was launched in 2005 with funding from GAIN and significant industry involvement from the Pakistan Flour Mills Association (PFMA). By the time the program was suspended in 2010, approximately 125 flour mills had begun fortifying flour, primarily using micro feeders purchased by the mills and premix subsidized by GAIN. The program came to a halt following the dissolution of the Federal Ministry of Health due to the 18th Constitutional Amendment in April 2010, which transferred several federal ministries to provincial governments. A key takeaway from the NWFFP regarding the regulatory environment for food fortification was the critical role of legislation in mandating fortification. With advocacy efforts from the program, a national standard was developed. The Pakistan Standards and Quality Control Authority (PSQCA) developed and notified a specification for fortified wheat flour in 2008, but no national legislation was passed before the devolution and suspension of the program. A 2009 evaluation report on the NWFFP (Zafar, 2009) highlighted the critical importance of legislation for the success of future wheat flour fortification efforts in Pakistan. The report emphasized that legislation would both compel millers to fortify wheat flour and provide a legal framework for enforcing quality assurance standards. It recommended pursuing provincial legislation as a priority but also suggested advocating for amendments to the existing Pure Food Rules through provincial chief ministers or at the district or municipal level, similar to the approach used in the USI program. In partnership with the Government of Punjab, GAIN-supported wheat flour fortification resumed in October 2013, focusing on both legislation and strengthening capacity in quality assurance and mill-level control.

Globally, wheat flour fortification is widespread, with approximately 75 countries mandating the fortification of wheat flour with at least iron and folic acid (see: www.ffinetwork.org/global_progress). Although establishing causality in food fortification programs is methodologically challenging, evidence from before-and-after studies in Central Asia (Tazhibayez et al., 2008), Venezuela (Layrisse et al., 2002), and Iran (Sadighi et al., 2009) suggests that fortifying wheat flour can significantly improve iron status in populations, as measured by serum ferritin levels. Pooled analyses of randomized and quasi-experimental studies on iron-fortified staple food consumption among children show significant increases in serum ferritin levels and hemoglobin concentrations, as well as lower anemia prevalence. Some studies also indicate positive effects on cognition (Das et al., 2013)

What is Chakki Atta

Chakki Atta is whole wheat flour traditionally ground using a stone mill, called a chakki. Sunridge, however, uses a pesa mill technique, which is a type of grinding machine where wheat grains are crushed between two stones or grinding surfaces to produce flour. This method retains the wheat's bran and germ, creating a more nutritious flour that tends to be coarser than flour produced by industrial mills. Chakki atta is widely used in Indian cuisine to make breads like chapati, roti, and paratha. The grinding process helps preserve both the flavor and the health benefits of the wheat.

Sunridge Foods

Sunridge Foods began its operations at Port Qasim, Karachi in 2015 and introduced its first product, Sunridge Whole Wheat Flour, in 2017. Since then, the company has consistently produced high-quality whole wheat flour, retained all its natural fiber, vitamins, and minerals, and met a significant portion of household nutritional needs. Sunridge Chakki Atta is made using Pakistan's first and only state-of-the-art

PESA mill, which utilizes advanced Swiss technology to produce superior-quality flour

Purpose

This primary research aimed to explore ways to enhance the fiber content and fortification of flour to improve its health benefits and assess the results of such interventions. The fiber content of flour can be increased using several methods:

1. **Use Whole Grains**: Ensure the atta is made from whole wheat rather than refined flour, as whole wheat naturally contains more fiber. – This is already practiced at Sunridge Foods.
2. **Add Bran**: Incorporate wheat bran, the outer layer of the wheat grain, which is rich in fiber and can easily be mixed into the flour. – This is the focus of the primary research.
3. **Include Other Grains**: Blend high-fiber grains like oats, barley, or millets with the wheat. These can be ground together to boost the overall fiber content. – Future testing is planned for developing a multigrain atta.
4. **Incorporate Legumes**: Add ground pulses or legumes like lentils or chickpeas, which are high in fiber and provide additional protein.
5. **Use Flaxseed or Chia Seeds**: Ground flaxseed or chia seeds are excellent sources of dietary fiber and can be added to the flour.
6. **Add Psyllium Husk**: Mixing psyllium husk into the flour can significantly increase fiber content. It is a soluble fiber that aids digestion.
7. **Choose Coarser Grind**: A coarser grind of chakki atta retains more bran and germ, thus increasing its fiber content compared to a finer grind.
8. **Add Premix**: Fortifying with Premix can further enhance the nutritional value of the flour.

By adopting these methods, the nutritional profile of chakki atta can be improved, resulting in higher fiber content.

Primary Research – Adding Bran/premix to Chakki Atta

This study examines the effect of varying percentages of bran/premix added to Chakki Atta on its fiber content, texture, and consumer acceptance. The goal is to determine the optimal bran percentage that enhances fiber without compromising the flour's functionality and flavor.

Introduction

Sunridge Chakki Atta, made from whole wheat, is a staple food in many households, especially in Pakistan. By adding bran to Chakki Atta, its fiber content can be increased, providing significant health benefits such as better digestion and increased satiety. This research aims to evaluate different bran percentages in Chakki Atta to find the ideal formulation for a high-fiber product.

Quality Assurance

- Premix is sourced from an approved supplier and is accompanied by a Certificate of Analysis (CoA) for each batch/lot purchased by the mill.
- The amount of premix procured aligns with the regular flour production capacity of the mill.
- Premix is stored properly and used before the expiry date.
- Premix feeders are installed, checked for proper functioning, and maintained periodically.
- The premix is dosed/added according to the fortified flour production rate.
- Fortified flour is packaged, labeled, and stored by specified guidelines.

Quality Control

- Records are maintained for both single and composite flour samples.
- Flour is consistently tested for fortification through qualitative methods.
- The average nutrient content is monitored to ensure it falls within an acceptable variation range around the target levels set by the national fortification standards.

Methodology

1. **Sample Preparation**

- **Ingredients**: Whole wheat grains and wheat bran were procured from a local mill.
- **Bran Percentages Tested**: The following bran percentages were tested: 0% (control), 3%, 5%, 10%, and 15% bran added to the atta.
- **Grinding Process**: Each mixture was ground using a traditional chakki mill to ensure consistency.

2. **Fiber Content Analysis**

- **Method**: Fiber content in each sample was determined using the AOAC method for dietary fiber analysis.
- **Sample Size**: Three batches were prepared for each percentage to ensure the results' reliability

3. **Sensory Evaluation**

- **Participants**: A group of volunteers, including bakers and consumers, took part in the sensory evaluation.
- **Evaluation Criteria**: The participants rated texture, taste, and overall acceptability on a scale of 1 to 5.
- **Taste Test**: Participants were given chapatis made from each flour variant and asked to provide feedback.

Results

1. Fiber Content

The results of dietary fiber analysis showed a significant increase in fiber content with the addition of bran:

Bran %	0%	3%	5%	10%	15%
Fiber per 100g	10g	12g	14g	16g	18g

2. Sensory Evaluation

Texture Ratings:

Bran %	0%	3%	5%	10%	15%
Texture rating	4.5	4.4	4.2	3.8	3.0

Taste Ratings:

Bran %	0%	3%	5%	10%	15%
Taste rating	4.6	4.5	4.3	3.7	3.2

Overall Acceptability:

Bran %	0%	3%	5%	10%	15%
Overall Acceptability rating	4.5	4.4	4.1	3.5	2.9

FIBER-FIT DEVELOPMENT DATA				
Parameters	**Brand Dosing 3%**	**Brand Dosing 5%**	**Brand Dosing 10%**	**Brand Dosing 15%**
Moisture %	9.4	9.5	9.56	9.6
Water Absorption %	86.75	89.88	90.01	90.56
Ash %	1.75	1.9	2.4	2.7
Granulation at 315mm sieve %	97.9	95.3	91.7	87.6
Granulation at 280mm sieve %	94.86	92.1	89.66	82.55
Granulation at 250mm sieve %	91.58	88.4	82	79.5
Granulation at 150mm sieve %	70.17	65.88	60.1	59.6
Smell	Flour Characteristic smell	Slightly brany smell	Brany/Earthy characteristic smell	Heavy Brany smell
Colour	Slightly brown	Brown	Brown	Slightly darker brown
Appearance	Slightly white powder	Slightly white powder with few bran spot	Slightly white powder with noticeable bran spots	Brown powder with unsightly bran spots
Shelf Life	4 Months	3 Months	2.5 Months	2 Months
Remarks	The Roti was soft The roti colour did not vary much from Fortified Chakki Atta The roti tastes was accordingly to whole-wheat atta roti characteristics	The Roti was soft The roti colour was slightly darker from Fortified Chakki Atta The roti tastes was accordingly to whole-wheat atta roti characteristics but with a slight bitter aftertaste	The Roti texture was not up to the mark and roti structure was not stable The roti colour was noticeably darker from Fortified Chakki Atta The roti had brany and earthy smell with a bitter aftertaste	The Roti texture was not up to the mark and dough structure cracked while flattening The roti colour was noticeably darker from Fortified Chakki Atta and burned bran spots were visible The roti had strong brany and earthy smell with a strong bitter aftertaste

Discussion

The study clearly shows that increasing the percentage of bran in chakki atta significantly boosts its fiber content. However, the sensory evaluation reveals that while a 3% increase in bran is well-received, higher percentages result in a decline in both texture and taste. The optimal level appears to be 3% bran, which strikes a balance between enhancing fiber and preserving the sensory qualities of the flour.

Conclusion

In conclusion, the analysis of options for scaling up fortification is an important step toward a comprehensive national nutrition strategy aimed at high-risk groups, particularly women of reproductive age and young children. Our findings strongly support the use of large-scale food fortification, building on the recent success of the flour fortification program. Given the widespread deficiencies in vitamins A and D in Pakistan, food fortification provides a practical solution to deliver these micronutrients on a large scale. While zinc deficiency is also prevalent, agricultural solutions offer a more feasible strategy for addressing zinc deficiencies compared to supplementation, though further evaluation is needed. Ultimately, success will also require greater focus on improving infant and young child feeding practices and ensuring the quality of fortified foods for young children.

Incorporating bran/premix into chakki atta effectively increases its fiber content and nutrients, with 3% being the most favorable percentage for maintaining taste and texture. Future research could focus on educating consumers about the health benefits of higher fiber intake, encouraging the adoption of bran-enriched chakki atta.