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A study on the addition of moringa leaf powder and quinoa flour in chapati dough for enhanced nutritional value

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Abstract

The study aimed to evaluate the nutritional enhancement of chapatis by incorporating moringa leaf powder (*Moringa oleifera*) and quinoa flour (*Chenopodium quinoa*), focusing on improving protein, fiber, vitamins, and minerals. The specific objectives included assessing the impact of these functional ingredients on the nutritional composition and sensory attributes of chapatis, as well as determining the optimal proportion of moringa leaf powder and quinoa flour for fortification. Three chapati formulations were prepared: (1) control chapati (100% wheat flour), (2) chapati with 5% moringa leaf powder and 5% quinoa flour, and (3) chapati with 10% moringa leaf powder and 10% quinoa flour. Nutritional analysis was performed to measure protein, fiber, vitamins, and minerals, while sensory evaluation was conducted using a 9-point hedonic scale to assess taste, texture, color, and overall acceptability. The results showed that the chapatis with 5% moringa and 5% quinoa flour exhibited significant improvements in protein (9.5 g/100 g) and fiber (4.1 g/100 g), with notable increases in micronutrients such as Vitamin C, calcium, and iron. The chapatis with 10% moringa and 10% quinoa flour showed the highest nutritional values, including 11.2 g of protein and 5.2 g of fiber per 100 g. However, the sensory evaluation revealed a decline in acceptability as the proportion of moringa and quinoa increased, with the 5% formulation being the most preferred. The study concluded that the incorporation of moringa and quinoa into chapati dough can significantly enhance its nutritional profile, but careful attention must be given to sensory characteristics for optimal consumer acceptance. Further research should explore alternative processing methods and other ingredient combinations to balance both nutrition and taste.

Keywords: Moringa leaf powder, quinoa flour, chapati, nutritional enhancement, protein, fiber, micronutrients, sensory evaluation, fortification

Introduction

The demand for functional foods with enhanced nutritional profiles is on the rise due to growing awareness about health and wellness. Among various staple foods, chapati, a type of unleavened flatbread, holds significant cultural and dietary importance in many parts of South Asia and across the globe. Chapati is primarily made from wheat flour, which, while a good source of carbohydrates, lacks substantial micronutrients and fiber. The nutritional quality of chapati can be significantly improved by incorporating alternative flours and nutrient-rich plant-based ingredients. In recent years, there has been increasing interest in fortifying staple foods with functional ingredients such as moringa (*Moringa oleifera*) leaf powder and quinoa (*Chenopodium quinoa*) flour, which are known for their high nutritional value, including vitamins, minerals, proteins, and antioxidants. Moringa leaf powder, derived from the Moringa tree, has been identified as a rich source of vitamins A, C, and E, calcium, and iron, making it a promising candidate for enhancing the micronutrient content of staple foods^[1, 2]. Quinoa, a pseudocereal, has gained recognition due to its excellent protein quality, high fiber content, and complete amino acid profile^[3, 4]. These properties make it an ideal candidate for incorporation into chapati dough to improve its overall nutritional content. However, despite the acknowledged benefits of both moringa and quinoa, there is limited research focused on their combination in chapati dough, particularly for enhancing both

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macro- and micronutrient profiles. Therefore, this study aims to investigate the effects of adding moringa leaf powder and quinoa flour in chapati dough, exploring the resultant changes in nutritional value, including fiber, protein, vitamins, and minerals. The objectives of this study are to evaluate the nutritional enhancement of chapati made with moringa leaf powder and quinoa flour, assess consumer acceptability, and determine any changes in the physicochemical properties of the chapati. The hypothesis of the study is that the incorporation of moringa leaf powder and quinoa flour will improve the nutritional profile of chapati, resulting in a product with higher fiber, protein, vitamins, and minerals, while maintaining consumer acceptability in terms of taste, texture, and appearance.

Materials and Methods

Materials

The materials used for this study include moringa leaf powder (*Moringa oleifera*), quinoa flour (*Chenopodium quinoa*), wheat flour (*Triticum aestivum*), and other ingredients required for chapati preparation. Moringa leaf powder was procured from a local supplier specializing in organic plant-based products, ensuring it was of high quality and free from contaminants. The quinoa flour was obtained from a certified organic quinoa supplier, and its nutritional properties were verified according to the supplier's specifications. Wheat flour, commonly used for chapati preparation, was sourced from a reputable local flour mill. Additional ingredients for chapati preparation, including salt, water, and a small amount of oil, were purchased from a local grocery store. Nutritional analysis of moringa leaf powder and quinoa flour, including protein, fiber, and micronutrient content, was conducted through a certified laboratory to ensure accurate data for the study.

Methods: The experiment followed a randomized design in which three different formulations of chapati dough were prepared:

- 1) Control chapati (100% wheat flour),
- 2) Chapati with 5% moringa leaf powder and 5% quinoa flour, and

- 3) Chapati with 10% moringa leaf powder and 10% quinoa flour.

The incorporation of moringa leaf powder and quinoa flour into chapati dough was carried out by gradually mixing the ingredients with wheat flour, using a hand-kneading method. The dough was then rested for 30 minutes before being divided into equal portions and rolled into thin discs. The chapatis were cooked on a hot griddle (tava) for 2-3 minutes on each side, ensuring even cooking at medium heat. After preparation, chapatis from each group were subjected to sensory evaluation and proximate analysis. The proximate analysis, including assessments of protein, fiber, vitamins, and minerals, was performed using standard laboratory methods. Sensory evaluation was carried out using a 9-point hedonic scale by 30 trained panelists, assessing parameters such as taste, texture, color, and overall acceptability. Statistical analysis was performed using Analysis of Variance (ANOVA) to compare the nutritional enhancement and acceptability scores between the different formulations.

Results

The results of the study are based on the nutritional analysis and sensory evaluation of the three different chapati formulations. The data are presented in terms of the proximate composition (Protein, fiber, vitamins, and minerals) and sensory characteristics (Taste, texture, color, and overall acceptability). Statistical analysis was performed using Analysis of Variance (ANOVA) to evaluate the differences between the three formulations, followed by post-hoc tests where applicable.

Nutritional composition

The nutritional composition of the chapatis made with moringa leaf powder and quinoa flour in different proportions is summarized in Table 1. The proximate analysis revealed a significant increase in protein, fiber, and micronutrient content in the chapatis containing moringa leaf powder and quinoa flour compared to the control chapati.

Table 1: Table compares the nutrient content per 100g of different types of chapati: Control Chapati (100% wheat flour), Chapati with 5% Moringa + 5% Quinoa, and Chapati with 10% Moringa + 10% Quinoa, highlighting protein, fiber, vitamin C, calcium, and iron levels

Nutrient	Control chapati (100% wheat flour)	Chapati with 5% moringa + 5% quinoa	Chapati with 10% moringa + 10% quinoa
Protein (g/100 g)	7.2	9.5	11.2
Fiber (g/100 g)	2.5	4.1	5.2
Vitamin C (mg/100 g)	0.2	6.5	12.0
Calcium (mg/100 g)	22.5	55.0	75.0
Iron (mg/100 g)	1.1	3.5	5.3

The chapatis prepared with 5% moringa leaf powder and 5% quinoa flour showed a marked increase in protein (9.5 g/100 g) and fiber (4.1 g/100 g) compared to the control chapati. Furthermore, the 10% moringa leaf powder and 10% quinoa flour chapatis exhibited the highest nutritional enhancement, with 11.2 g of protein and 5.2 g of fiber per 100 g of chapati. Additionally, there was a significant increase in micronutrients, particularly Vitamin C, calcium, and iron, which were notably higher in the formulations with moringa leaf powder and quinoa flour. The results suggest that the

incorporation of these ingredients into chapati dough effectively enhances its nutritional profile.

Sensory evaluation

The sensory evaluation results are summarized in Table 2, where a 9-point hedonic scale was used to assess taste, texture, color, and overall acceptability. The data showed a significant difference in the sensory attributes of the chapatis, with the 5% moringa and 5% quinoa formulation being the most acceptable among the panelists.

Table 2: Table describes the sensory attributes (Taste, texture, color, and overall acceptability) of three types of chapatis: Control Chapati (100% wheat flour), Chapati with 5% Moringa + 5% Quinoa, and Chapati with 10% Moringa + 10% Quinoa, with respective ratings for each attribute

Sensory attribute	Control chapati (100% wheat flour)	Chapati with 5% moringa + 5% quinoa	Chapati with 10% moringa + 10% quinoa
Taste	7.8	7.5	6.2
Texture	7.0	7.2	6.5
Color	8.0	7.8	7.0
Overall acceptability	7.4	7.6	6.0

While the chapatis with moringa and quinoa flour showed an improvement in their nutritional content, the sensory evaluation indicated a slight reduction in taste, texture, and overall acceptability as the percentage of moringa and quinoa increased. The 5% moringa and 5% quinoa formulation scored the highest in all sensory attributes, particularly in taste (7.5) and overall acceptability (7.6). The 10% moringa and 10% quinoa chapatis received lower scores in these areas, indicating that higher concentrations of moringa and quinoa may alter the flavor and texture to a degree that affects consumer acceptability.

Statistical analysis

The data were analyzed using One-Way Analysis of Variance (ANOVA) to compare the nutritional composition and sensory scores between the three chapati formulations. The results of the ANOVA for the proximate composition showed a significant difference between the formulations ($p < 0.05$). Post-hoc comparisons using Tukey's test revealed that the chapatis with 10% moringa and 10% quinoa flour had significantly higher protein, fiber, calcium, and iron content compared to the control and the 5% moringa + 5% quinoa formulations.

Similarly, the sensory evaluation data showed a significant difference in overall acceptability ($p < 0.05$) between the formulations. The 5% moringa + 5% quinoa chapatis were significantly more acceptable than the other two formulations, according to the pairwise comparisons. However, the difference in taste and texture scores between the 5% and 10% formulations was not statistically significant, although there was a noticeable trend towards a decrease in acceptability as the percentage of moringa and quinoa increased.

The addition of moringa leaf powder and quinoa flour to chapati dough resulted in a significant improvement in the nutritional profile of the chapatis, particularly in terms of protein, fiber, vitamins, and minerals. However, higher concentrations of moringa and quinoa resulted in a reduction in sensory acceptability, especially in taste and texture. Based on the results, the incorporation of 5% moringa leaf powder and 5% quinoa flour is recommended for optimal nutritional enhancement without compromising sensory attributes. These findings suggest that such fortification could serve as a valuable strategy for improving the nutritional quality of staple foods, particularly in regions with high malnutrition rates. Further studies could explore alternative processing methods or other ingredient combinations to improve both the nutritional value and sensory acceptability of such fortified products.

Discussion

The incorporation of moringa leaf powder and quinoa flour into chapati dough demonstrated significant improvements in the nutritional profile of the chapatis, especially in terms of protein, fiber, and micronutrient content, as highlighted in the results. The increase in protein, fiber, and essential

micronutrients such as Vitamin C, calcium, and iron in chapatis prepared with moringa and quinoa flour aligns with findings from previous studies that have explored the fortification of staple foods with these ingredients [7]. For instance, Fahey (2011) [1] highlighted the remarkable nutritional properties of moringa leaves, including their high vitamin content, making them a valuable addition to food products aimed at addressing micronutrient deficiencies [1]. Similarly, Cici *et al.* (2019) [3] reported that quinoa is a highly nutritious pseudocereal with high protein content and a complete amino acid profile, which makes it an excellent candidate for food fortification [3].

The significant increase in protein and fiber content in chapatis with the addition of moringa leaf powder and quinoa flour is consistent with the findings of Kumbhar *et al.* (2021) [8], who incorporated quinoa flour into various baked goods and reported improvements in their nutritional composition, particularly in terms of fiber and protein [8]. Moreover, the increase in micronutrient content, especially calcium and iron, observed in this study corroborates the results from George *et al.* (2021) [13], who found that moringa leaf powder significantly enhanced the mineral content of foods, including calcium and iron, when incorporated into various food matrices [13].

The sensory evaluation results indicated a trade-off between the nutritional enhancement of the chapatis and their acceptability. While the 5% moringa and 5% quinoa formulation was the most acceptable, the 10% moringa and 10% quinoa formulation received lower sensory scores, particularly for taste and overall acceptability. This is in line with previous studies, such as those by Joshi *et al.* (2020) [20], who found that while quinoa flour improved the nutritional content of gluten-free bakery products, higher concentrations of quinoa negatively impacted sensory attributes, particularly taste [20]. Similarly, Silva *et al.* (2018) [10] reported that the incorporation of moringa leaf powder into food products enhanced their nutritional quality, but higher concentrations led to a reduction in consumer acceptability due to the strong flavor of moringa [10]. These findings suggest that while the nutritional benefits of these ingredients are evident, consumer preferences play a critical role in the successful adoption of such fortified products.

Critically analyzing these results, it is important to consider several factors. The improvements in nutritional content are substantial, but the sensory acceptability of the product must also be taken into account for consumer adoption. The results of the sensory evaluation imply that there is an optimal concentration of moringa and quinoa for fortification that balances both nutritional enhancement and sensory acceptability [1, 2, 3, 9]. It is also essential to note that the addition of moringa leaf powder and quinoa flour to chapati dough may affect its texture and consistency, which can be a concern in large-scale food production. Further research is required to explore the effect of different processing techniques, such as baking or steaming, on the sensory and nutritional characteristics of fortified chapatis.

In future studies, it would be beneficial to explore the impact of different processing methods (e.g., baking temperature, moisture content, and fermentation) on the nutritional content and sensory attributes of fortified chapatis. Additionally, it would be valuable to explore the inclusion of other bioactive ingredients, such as turmeric, ginger, or other locally available plants with known health benefits, to further enhance the nutritional profile of staple foods [14]. Another promising direction could be the development of consumer-friendly product formulations by optimizing the concentration of moringa leaf powder and quinoa flour to improve taste while still providing significant nutritional benefits [11, 20]. Consumer preference studies should also be conducted in different regions to assess the acceptability of these fortified chapatis, which can inform the scaling up of such fortification strategies in food industries.

Conclusion

The findings of this study demonstrate that the incorporation of moringa leaf powder and quinoa flour into chapati dough significantly enhances its nutritional profile, making it a promising approach to fortifying a staple food product commonly consumed across many parts of South Asia and globally. The addition of these functional ingredients resulted in notable increases in protein, fiber, and essential micronutrients such as calcium, iron, and Vitamin C, which are often deficient in many populations, particularly in developing regions. Moringa leaf powder, known for its high concentration of vitamins and minerals, and quinoa flour, recognized for its complete amino acid profile and protein quality, provided a synergistic boost to the nutritional value of chapatis. These findings align with previous research that supports the potential of moringa and quinoa as valuable ingredients in food fortification, particularly in regions where malnutrition and micronutrient deficiencies are prevalent. The results not only confirm that moringa leaf powder and quinoa flour enhance the nutritional content of chapati but also suggest that such fortification could contribute to improving public health outcomes by providing an affordable, culturally accepted means of addressing nutritional deficiencies.

However, while the nutritional enhancement was significant, sensory evaluation results indicated a challenge in balancing nutritional improvement with sensory acceptability. The formulation with 5% moringa leaf powder and 5% quinoa flour emerged as the most acceptable in terms of taste, texture, and overall consumer preference. On the other hand, higher concentrations (10% moringa and 10% quinoa) led to a decrease in acceptability, particularly in terms of taste and texture. This finding highlights the importance of maintaining a balance between the nutritional benefits of fortification and the sensory qualities that influence consumer acceptance. Previous studies have also indicated similar challenges when fortifying food products with plant-based powders, such as moringa and quinoa, which possess distinct flavors that may not align with conventional preferences. Therefore, the use of moringa and quinoa in moderate amounts, as demonstrated in this study, appears to be optimal for achieving a nutritional boost while ensuring that the product remains palatable to the general population. From a practical standpoint, this study provides a solid foundation for the potential incorporation of moringa leaf powder and quinoa flour into not only chapati but also other

staple foods such as bread, pasta, and snacks, particularly in regions where malnutrition is prevalent. Given the significant increase in essential nutrients like calcium, iron, and fiber, it would be beneficial for policymakers and food industries to explore the integration of such fortification strategies in school meal programs, community kitchens, and government-supported nutrition initiatives. Additionally, the findings emphasize the need for further research into the optimization of ingredient proportions to improve both nutritional content and sensory acceptability. Future studies could explore the use of alternative processing methods, such as fermentation or enzymatic treatments, to reduce the strong flavor of moringa and improve the texture of quinoa-enriched products without compromising their nutritional benefits. Furthermore, consumer acceptance studies across diverse populations and regions would help identify the ideal formulation and guide the scaling-up of such fortification efforts.

The research also opens avenues for future product development. In particular, the exploration of other bioactive ingredients such as turmeric, ginger, or fenugreek in combination with moringa and quinoa could yield further enhanced products. Additionally, incorporating other nutrient-dense ingredients like flaxseed, chia seeds, or even algae into the chapati dough could create a multifaceted, nutrient-rich product. To address potential consumer concerns, it would be essential to conduct large-scale trials, including Randomized Controlled Trials (RCTs), to evaluate not only the nutritional impact but also the health benefits of such fortified foods over time. Finally, this study underlines the importance of an interdisciplinary approach, involving nutritionists, food scientists, and consumer behavior experts, to develop fortified products that are both nutritionally beneficial and widely accepted by the target population.

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