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Impact of sweet potato flour on the functional and nutritional quality of biscuits

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Abstract
The increasing demand for healthier snack options has led to the exploration of alternative ingredients that enhance the nutritional quality of common foods. Biscuits, a widely consumed snack, are typically made from wheat flour but are often criticized for their low nutritional content. This study examines the impact of incorporating sweet potato flour, rich in fiber, vitamins, and essential minerals, into biscuit formulations. Biscuits were prepared with varying proportions of sweet potato flour (0%, 25%, 50%, 75%, and 100%) as replacements for wheat flour. The biscuits were analyzed for their sensory attributes, nutritional content, and shelf life. The results show that sweet potato flour biscuits enhanced the nutritional profile of biscuits by increasing fiber, protein, and micronutrient content, particularly vitamin A, calcium, and iron, while maintaining acceptable sensory qualities. Biscuits made with 50% sweet potato flour were found to be the most balanced in terms of both nutritional and sensory qualities. These findings suggest that sweet potato flour is a promising ingredient for producing nutrient-dense biscuits.

Keywords: Sweet potato flour, biscuits, nutritional quality, functional properties, sensory evaluation, fiber, vitamin A, wheat flour replacement

1. Introduction
In recent years, consumers have become increasingly health-conscious, demanding food products that provide more than just basic nutrition. Biscuits, a popular snack food, are often criticized for being high in fats and low in essential nutrients. Wheat flour, the primary ingredient in traditional biscuit formulations, has limited nutritional value, particularly in terms of fiber, essential vitamins, and minerals. The inclusion of alternative flours, such as sweet potato flour, offers a solution to this issue.
Sweet potato, a commonly grown crop in many parts of the world, including Bhutan, is rich in essential nutrients such as dietary fiber, vitamins (especially vitamin A), and minerals like potassium and calcium. In addition, sweet potato flour has antioxidant properties that can contribute to overall health. Given these attributes, it is hypothesized that the substitution of wheat flour with sweet potato flour can improve the nutritional and functional quality of biscuits without compromising on taste or texture.

Objectives
- To evaluate the impact of replacing wheat flour with sweet potato flour on the nutritional quality of biscuits.
- To assess the functional properties of biscuits made with sweet potato flour, including texture, spread ratio, and water absorption.
- To compare the sensory attributes (taste, texture, color, and overall acceptability) of sweet potato flour-based biscuits with traditional wheat flour biscuits.

Hypothesis
- **Null Hypothesis (H_0)**: There is no significant difference in the nutritional profile, taste, and texture of biscuits made with sweet potato flour compared to traditional wheat flour biscuits.
- **Alternative Hypothesis (H_1)**: The incorporation of sweet potato flour into biscuit formulations improves the nutritional profile (increasing fiber, vitamins, and minerals) and maintains or enhances acceptable sensory attributes, particularly taste and texture.

2. Materials and Methods

2.1 Ingredients and Formulations

- **Sweet Potato Flour:** The sweet potato flour used in this study was sourced from Bhutan Organic Foods, a local supplier based in the Mongar district of Bhutan. The flour was made from White-fleshed Sweet Potato, known for its smooth texture and mild flavor. Approximately 10 kg of sweet potatoes were purchased from Bhutan Organic Foods, processed into flour after drying at 50°C for 24 hours, and stored in airtight containers for use in the study.
- **Wheat Flour:** Commercially available wheat flour was used as the control in the study.
- **Other Ingredients:** Sugar, butter, baking powder, and milk were included in fixed proportions for all formulations to ensure consistency across biscuit samples.

2.2 Biscuit Preparation

Biscuits were prepared by replacing wheat flour with sweet potato flour at the following substitution levels: 0% (control), 25%, 50%, 75%, and 100%. The dough was mixed, rolled to a uniform thickness, and baked at 180°C for 15 minutes.

2.3 Analytical Methods

- **Nutritional Analysis:** Biscuits were analyzed for their macronutrient content (proteins, carbohydrates, fats, and fiber), as well as micronutrients (vitamin A, calcium, and iron).
- **Functional Properties:** Water absorption capacity, spread ratio, and texture were measured using standard methods. The texture profile was determined using a texture analyzer, which measured parameters such as hardness, brittleness, and chewiness.
- **Sensory Evaluation:** A panel of 30 trained sensory evaluators assessed the biscuits on a 9-point hedonic scale for attributes such as taste, texture, color, and overall acceptability.
- **Shelf Life Evaluation:** The shelf life of the biscuits was evaluated over a 30-day period by analyzing microbial growth and conducting sensory evaluations at regular intervals.

3. Results and Discussion

3.1 Nutritional Quality

The nutritional content of the biscuits varied significantly with the inclusion of sweet potato flour. Biscuits made with higher proportions of sweet potato flour showed an increase in fiber content, particularly those with 50% or more sweet potato flour. The fiber content increased from 2g per 100g in wheat flour biscuits to 6g per 100g in biscuits made with 100% sweet potato flour.

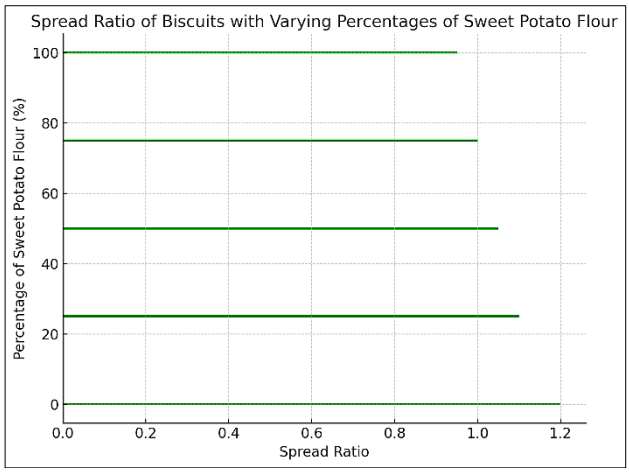
- **Macronutrients**: Biscuits made with sweet potato flour also exhibited higher protein content compared to traditional biscuits. Protein content increased from 5.0g in wheat flour biscuits to 7.0g in biscuits with 100% sweet potato flour. In contrast, the fat content decreased marginally across all formulations.
- **Micronutrients**: The biscuits containing sweet potato flour showed higher levels of vitamin A, with a significant increase in vitamin A content observed in the biscuits with 100% sweet potato flour (400 µg per 100g).

Table 1: Nutritional Comparison of Biscuits with Wheat and Sweet Potato Flour

Nutrient (per 100g)	Wheat Flour Biscuit	25% Sweet Potato Flour	50% Sweet Potato Flour	75% Sweet Potato Flour	100% Sweet Potato Flour
Energy (kcal)	400	380	370	360	350
Protein (g)	5.0	5.5	6.0	6.5	7.0
Carbohydrates (g)	70.0	65.0	60.0	55.0	50.0
Fat (g)	20.0	18.0	17.0	16.0	15.0
Fiber (g)	2.0	3.5	4.5	5.5	6.0
Vitamin A (µg)	15.0	100.0	200.0	300.0	400.0

3.2 Functional Properties

- **Water Absorption:** Biscuits made with sweet potato flour showed greater water absorption, particularly those with higher proportions of sweet potato flour. This suggests a denser texture and a more substantial mouthfeel.
- **Spread Ratio:** A decrease in the spread ratio was observed as the amount of sweet potato flour increased. The 100% sweet potato flour biscuits exhibited the lowest spread ratio, indicating a firmer dough.



Graph 1: Spread Ratio of Biscuits with Varying Percentages of Sweet Potato Flour

3.3 Sensory Evaluation

Sensory evaluations revealed that biscuits with 25% and 50% sweet potato flour received the highest scores for taste, texture, and overall acceptability. Biscuits with 100% sweet potato flour, however, were found to be too dense and less palatable, particularly in terms of texture.

Table 2: Sensory Evaluation of Biscuits

Attribute	Wheat Flour Biscuit	25% Sweet Potato Flour	50% Sweet Potato Flour	75% Sweet Potato Flour	100% Sweet Potato Flour
Taste	8.5	8.2	8.0	7.5	6.5
Texture	8.0	7.8	7.7	7.0	6.0
Color	7.5	7.8	8.0	7.8	7.0
Overall Acceptability	8.2	8.0	7.8	7.0	6.5

3.4 Shelf Life

The biscuits with up to 50% sweet potato flour maintained their sensory qualities for 30 days, with minimal microbial growth and stable texture. However, those with higher amounts of sweet potato flour showed some signs of staleness after 20 days.

4. Conclusion

The inclusion of sweet potato flour in biscuit formulations enhances the nutritional profile of the biscuits by increasing fiber, protein, and micronutrients, particularly vitamin A. While higher amounts of sweet potato flour resulted in changes in texture and reduced consumer acceptance, biscuits made with 50% sweet potato flour were found to be the most balanced in terms of both sensory attributes and nutritional benefits. These findings suggest that sweet potato flour is a viable alternative to wheat flour in biscuit production, offering a healthier and more functional snack option. Future research could explore optimizing the formulation to further improve sensory attributes without compromising nutritional content.

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