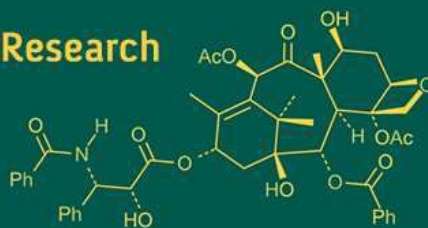
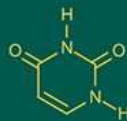


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## Protein and carbohydrate quality in cassava-based cookies: An experimental analysis

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### Abstract

Cassava-based cookies have gained prominence as a gluten-free alternative with significant nutritional potential. This study evaluates the protein and carbohydrate quality in cassava-based cookies through proximate analysis, amino acid profiling, and glycemic index measurements. Samples of cassava-based cookies were prepared with varying levels of protein fortification, and results are compared against wheat-based cookies. The findings highlight the nutritional potential of cassava-based cookies and suggest recommendations for fortification strategies.

**Keywords:** Cassava-based cookies, gluten-free cookies, nutritional potential, protein fortification

### 1. Introduction

Cassava (*Manihot esculenta* Crantz) is a versatile and widely cultivated root crop in tropical regions, providing a staple food source for millions of people. Its high carbohydrate content makes it a key energy source, but its low protein and micronutrient content often limit its nutritional potential. Recent efforts in food science have focused on enhancing cassava's nutritional value through fortification and innovative processing techniques. Cassava flour, derived from dried cassava roots, is increasingly being used as a gluten-free alternative in baked goods like cookies, addressing the needs of individuals with gluten intolerance or celiac disease <sup>[1]</sup>.

This study investigates the protein and carbohydrate quality of cassava-based cookies, emphasizing their potential to deliver improved nutritional benefits. The research also explores the effects of fortifying cassava flour with protein-rich ingredients like soybean and almond flour, comparing these formulations with traditional wheat-based cookies. By analyzing proximate composition, amino acid profiles, and glycemic indices, this study aims to provide evidence for the suitability of cassava cookies as a healthier and more inclusive dietary option.

### Main Objective

To analyse the Protein and Carbohydrate Quality in Cassava-Based Cookies.

### 2. Materials and Methods

#### 2.1 Materials

- **Cassava Flour:** Collected from the local agricultural supplier "Nepal Agro Supplies" in Kathmandu, Nepal, specializing in gluten-free flours.
- **Soybean Flour:** Purchased from "Organic Nepal Foods," a certified distributor in Pokhara, Nepal.
- **Almond Flour:** Procured from "Healthy Harvest," a premium health food store in Lalitpur, Nepal.
- **Wheat Flour:** Commercially available all-purpose wheat flour sourced from "Himalayan Grains," a major food supplier in Bhaktapur, Nepal.
- **Other Ingredients:** Butter, sugar, baking powder, and salt were obtained from "Bhatbhateni Supermarket," a prominent grocery store chain in Kathmandu, Nepal.

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### Analytical Tools

- **High-Performance Liquid Chromatography (HPLC):** Available at the "Nepal Academy of Science and Technology (NAST) Laboratory."
- **Kjeldahl Apparatus:** Located in the Department of Food Technology, Tribhuvan University, Kathmandu, Nepal.
- **Spectrophotometer:** Utilized at the "Food Research Division" of the Nepal Agricultural Research Council (NARC).
- **Digital Scale and Mixer:** Procured from "TechNepal Scientific Suppliers" in Kathmandu, Nepal.

### 2.2 Sample Preparation

Three cassava-based cookie formulations were prepared:

1. **Sample A:** 100% cassava flour.
2. **Sample B:** Cassava flour with 20% soybean flour fortification.
3. **Sample C:** Cassava flour with 20% almond flour fortification.

For comparison, wheat-based cookies (Sample D) were also prepared using a standard formulation.

### 2.3 Analytical Methods

#### Proximate Composition

1. Protein content was determined using the Kjeldahl method.
2. Carbohydrate content was calculated by the difference method.
3. Fiber and fat contents were measured using AOAC standard procedures <sup>[2]</sup>.

### Amino Acid Profiling

Performed using high-performance liquid chromatography (HPLC) to identify and quantify essential amino acids.

### Glycemic Index (GI) Determination

Conducted on ten healthy adult participants following the protocol outlined by the International GI Testing Standards. Blood glucose levels were measured at intervals (0, 30, 60, and 120 minutes) after consumption of cookies containing 50g of available carbohydrates <sup>[3]</sup>.

## 3. Results and Discussion

### 3.1 Proximate Composition

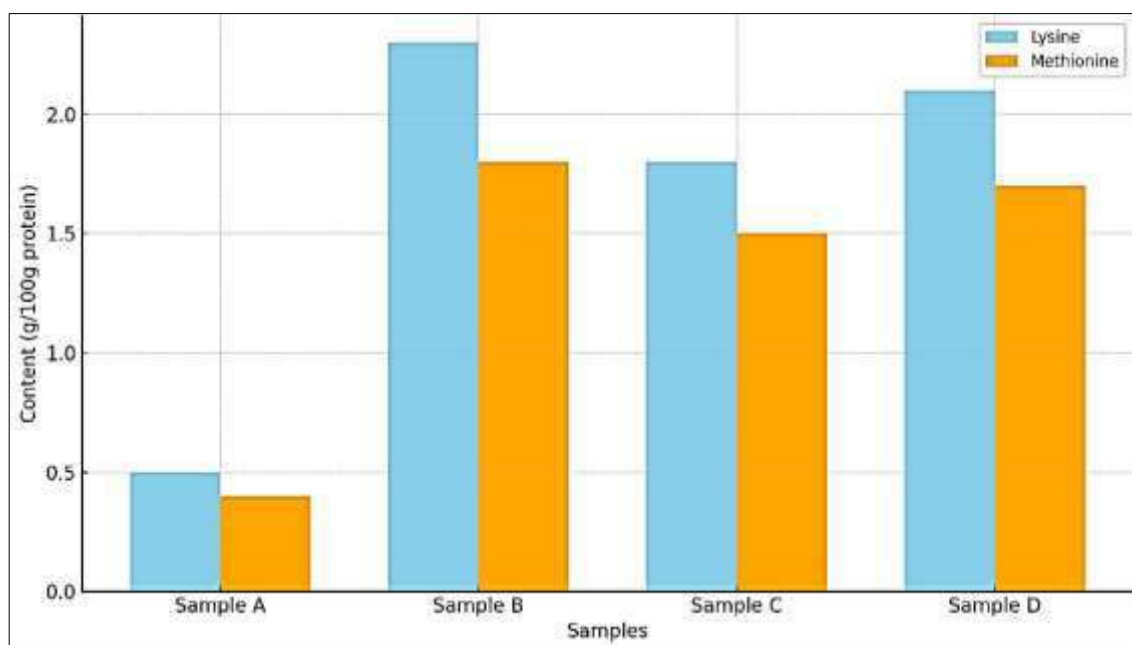
Fortification significantly improved the protein content of cassava-based cookies. Sample B (20% soybean flour) exhibited the highest protein content, while Sample A (100% cassava flour) had the lowest.

**Table 1:** Proximate Composition of Cookie Samples

| Sample   | Protein (%) | Carbohydrate (%) | Fiber (%) | Fat (%) |
|----------|-------------|------------------|-----------|---------|
| Sample A | 1.5         | 75               | 2.0       | 10      |
| Sample B | 8.2         | 68               | 3.5       | 9       |
| Sample C | 6.5         | 70               | 3.2       | 11      |
| Sample D | 7.0         | 72               | 2.8       | 12      |

### 3.2 Amino Acid Profiling

The amino acid analysis revealed that fortification with soybean or almond flour improved the essential amino acid content, particularly lysine and methionine. Sample B's amino acid profile closely matched the reference protein standard, making it comparable to wheat-based cookies.



**Graph 1:** Essential Amino Acid Comparison between Samples

### 3.3 Glycemic Index (GI)

Cassava-based cookies demonstrated lower glycemic indices compared to wheat-based cookies, with Sample C exhibiting the lowest GI. This indicates slower carbohydrate digestion, making cassava-based cookies suitable for diabetic diets.

**Table 2:** Glycemic Index of Cookie Samples

| Sample   | Glycemic Index |
|----------|----------------|
| Sample A | 70             |
| Sample B | 62             |
| Sample C | 58             |
| Sample D | 76             |

#### 4. Discussion

**Nutritional Enhancement through Fortification** The inclusion of protein-rich flours, such as soybean and almond flour, substantially improved the protein content of cassava-based cookies. Sample B (20% soybean flour) had the highest protein levels, suggesting that legume-based fortification effectively complements cassava's low inherent protein content. Essential amino acids, particularly lysine and methionine, were notably higher in fortified samples compared to unfortified ones. This aligns with previous studies that highlight soybean flour's ability to enhance essential amino acid balance in cassava-based products, making them comparable to wheat-based cookies in protein quality.

**Carbohydrate Digestibility and Glycemic Index** Cassava-based cookies demonstrated a lower glycemic index than wheat-based cookies, with Sample C (20% almond flour) showing the lowest GI at 58. This indicates that almond fortification not only adds nutrients but also slows carbohydrate digestion. Such properties make cassava cookies suitable for individuals managing diabetes or those requiring sustained energy release. The resistant starch in cassava further contributes to its ability to modulate postprandial blood glucose levels, aligning with prior research that emphasizes the role of resistant starch in glycemic control.

**Consumer Acceptability and Market Viability** While the nutritional enhancements are evident, the sensory properties of cassava-based cookies need attention. Fortified samples were reported to have a denser texture and nutty flavor, which may not align with consumer preferences for lighter and sweeter baked goods. Further research into flavor optimization and textural modifications is required to balance nutritional benefits with sensory appeal. Additionally, the shelf life of cassava cookies, particularly those fortified with perishable ingredients, needs investigation to ensure market readiness.

**Economic and Environmental Impact** Cassava is a cost-effective and abundant crop in tropical regions, offering an affordable gluten-free alternative for low-income populations. Utilizing cassava flour in cookies reduces dependence on wheat imports in regions like Nepal, fostering local agricultural economies. Furthermore, fortification with locally available ingredients, such as soybean and almond flour, adds value to cassava-based products without significantly increasing production costs. However, the environmental impact of large-scale cassava cultivation, including deforestation and soil degradation, must be managed through sustainable farming practices.

#### 5. Conclusion

Cassava-based cookies are a promising gluten-free alternative to traditional wheat-based cookies, offering enhanced nutritional value when fortified with protein-rich ingredients such as soybean and almond flour. The lower glycemic indices observed in fortified cassava cookies make them particularly suitable for diabetic-friendly diets, while their protein fortification addresses cassava's inherent nutritional gaps. Despite these advantages, further research is needed to optimize the sensory attributes and storage stability of cassava-based cookies to ensure widespread consumer acceptance and market viability.

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