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Nutritional and Functional Characterization of Black Lentil Seed and Germinated Powder and Their Utilization in Bread Fortification

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Abstract:

The present study aimed to evaluate the nutritional, mineral (micro- and macroelement), total polyphenol, and phytic acid contents of *Lens culinaris* L. (black lentil) seed powder and germinated black lentil powder, as well as to assess their potential as functional ingredients in breadmaking. The germinated lentil powder was obtained after controlled sprouting (72 h, 25 °C), dried, and milled to a fine powder, while the seed powder was prepared from non-germinated seeds. Both matrices were characterized for their compositional and bioactive profiles. The results revealed a significant reduction in phytic acid and a marked increase in total polyphenols and mineral bioavailability in the germinated powder compared to the non-germinated seeds.

To evaluate their technological applicability, two bread formulations were developed: one using sourdough fermentation and another using baker's yeast. In each system, the non-germinated lentil seed powder was incorporated at 10%, 20%, and 30%, while the germinated lentil powder was added at 2.5%, 5%, and 7.5%. The obtained bread samples were analyzed for proximate composition (moisture, protein, lipids, ash, carbohydrates), mineral content, total polyphenols, and phytic acid levels.

The inclusion of germinated lentil powder significantly enhanced the nutritional value and antioxidant potential of the breads while lowering the phytic acid content, particularly in sourdough-based formulations, which exhibited improved mineral bioavailability. The findings demonstrate that partial substitution of wheat flour with black lentil germinated powder represents a promising approach for developing nutritionally enhanced and functionally active bakery products.

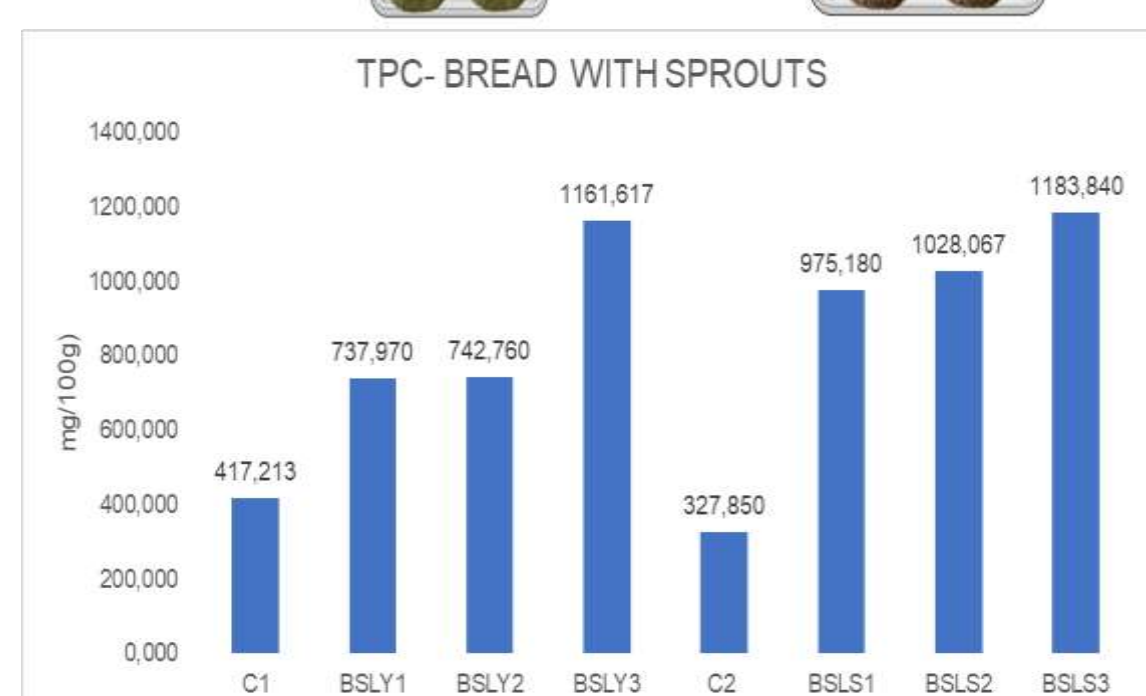
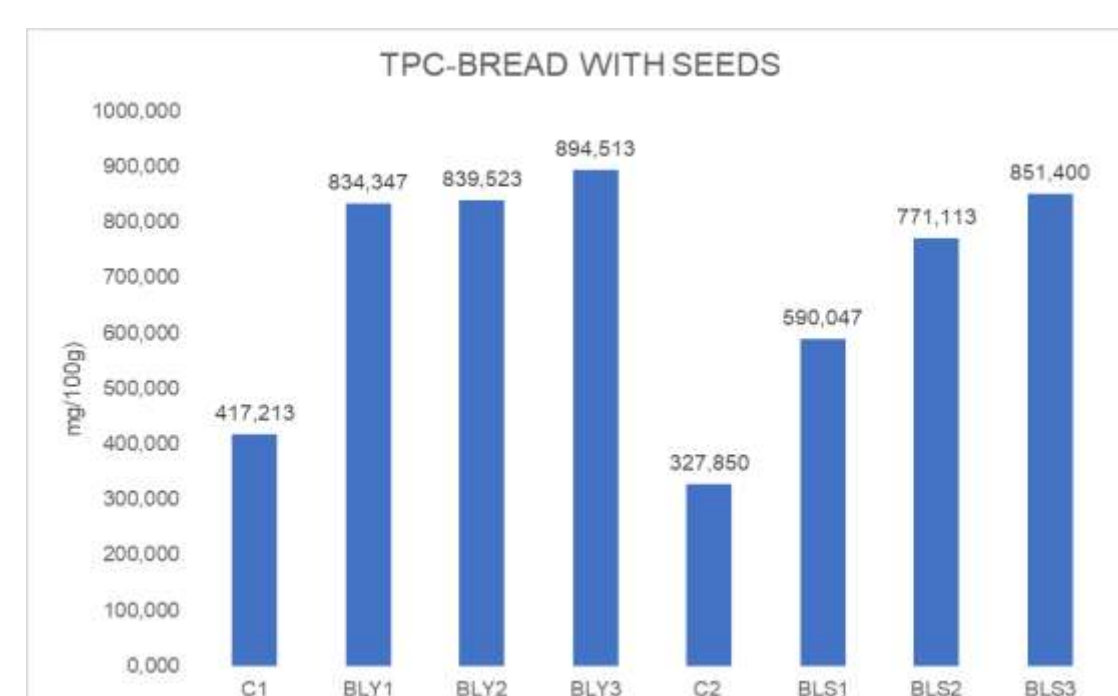
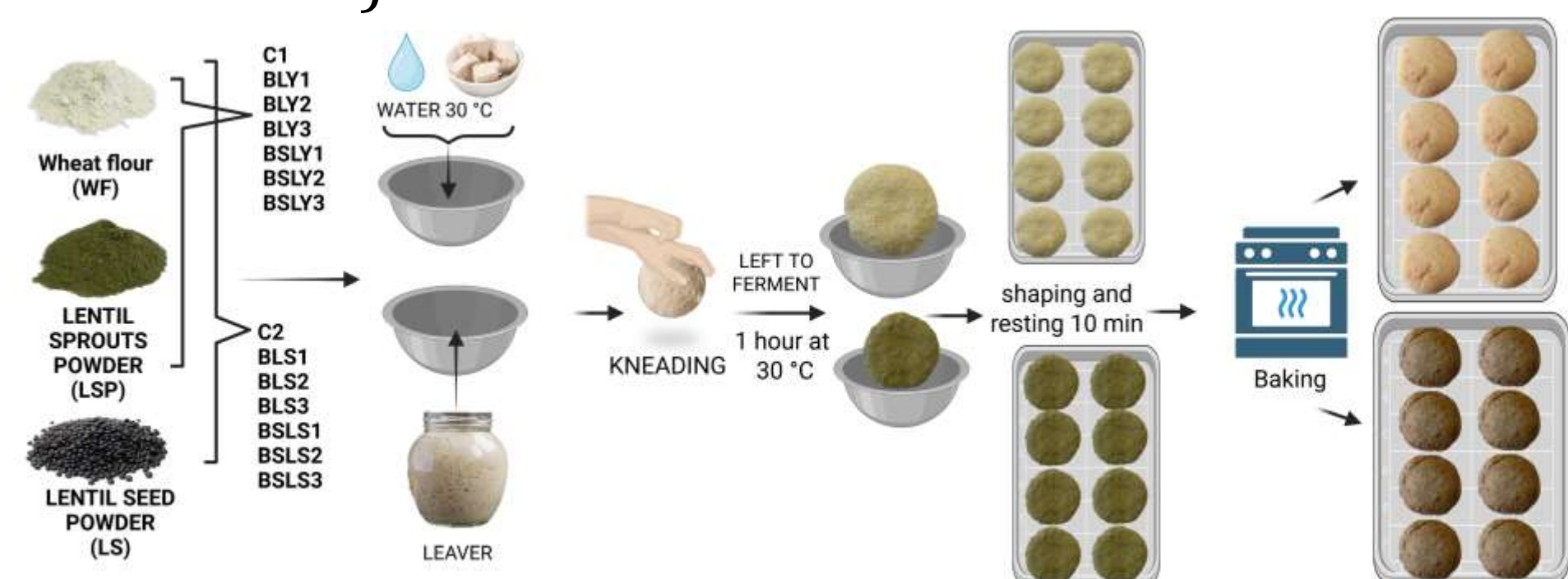
Introduction

Black lentils (*Lens culinaris* L.) are nutrient-rich legumes containing proteins, minerals, and bioactives. However, their high phytic acid levels reduce mineral bioavailability. Germination enhances enzymatic activity, decreases antinutrients, and increases total phenolics, improving the functional potential of lentil flours. This study evaluates the nutritional, mineral, polyphenol, and phytic acid contents of germinated black lentil powder and its application in sourdough and yeast breads to produce nutritionally enhanced bakery products.

Material and method

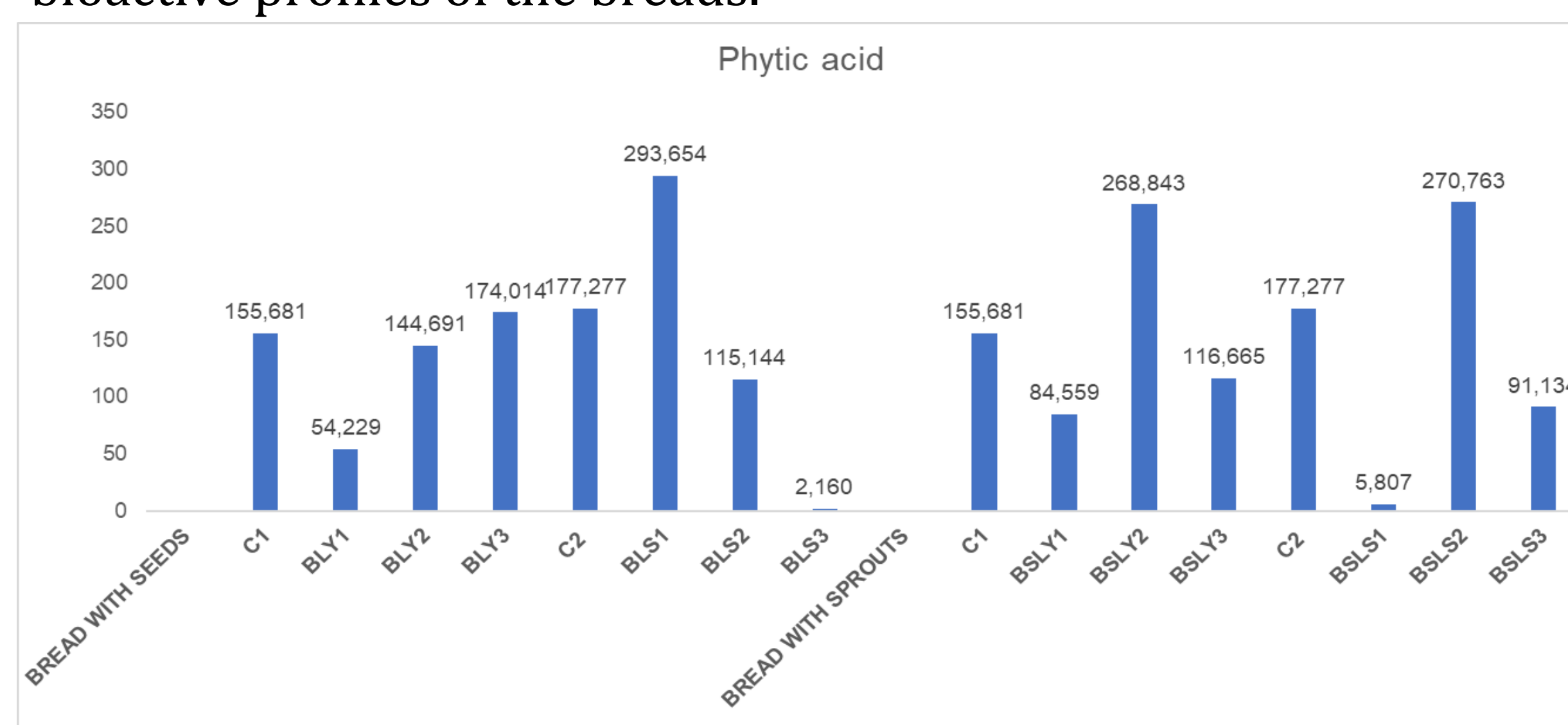
Black lentil (*Lens culinaris* L.) seeds were cleaned, soaked in distilled water (12 h, 25 °C), and germinated for 72 h at 25 °C under controlled humidity. The sprouts were dried at 40 °C and ground into a fine powder (BSprouts). Non-germinated seeds were milled directly to obtain seed powder (BSeeds). Bread formulation. Two types of breads were prepared: Sourdough breads, using natural fermentation, and Yeast breads, using baker's yeast. The BSeeds powder was incorporated at 10%, 20%, and 30%, while BSprouts powder was used at 2.5%, 5%, and 7.5% substitution levels of wheat flour.

Both were incorporated into sourdough and yeast breads (2.5–30% substitution).



Results and discussions

The compositional analysis revealed significant differences between the non-germinated (BSeeds) and germinated (BSprouts) black lentil powders. Germination led to a marked increase in total polyphenols and a reduction in phytic acid content, confirming the beneficial effect of enzymatic activation during sprouting. To further assess their functionality in bakery applications, the powders were incorporated into sourdough and yeast breads at various levels. The results demonstrated that both the germination process and fermentation type influenced the nutritional and bioactive profiles of the breads.



Conclusions

Phytic acid levels decreased markedly in breads enriched with germinated black lentil powder compared to those with non-germinated seeds. Germination, followed by sourdough fermentation, significantly reduced phytic acid (down to 2–6 mg/100 g) due to phytase activation and acidic conditions that promote phytate hydrolysis.

Total polyphenol content (TPC) increased substantially, from 590–895 mg GAE/100 g in seed-based breads to 975–1184 mg GAE/100 g in sprout-enriched samples. Sourdough breads showed higher TPC than yeast breads, indicating a synergistic effect of germination and fermentation in enhancing antioxidant potential. Overall, germination reduced antinutritional factors while improving bioactive content and mineral availability, demonstrating the potential of germinated black lentil powder as a functional ingredient in bakery products.

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