



***In-Vitro* Digestibility, Glycaemic Load and Amino Acid Composition of Oven-Baked Chips Produced from Germinated Lima Bean Flour Substituted Whole Wheat Flour**

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ABSTRACT

Chips are popular snacks consumed across all ages, and the incorporation of germinated lima beans (GLB) presents the opportunity to increase the nutritional content for healthy snacking. This study aims to evaluate the *in-vitro* digestibility, glycaemic load, and amino acid composition of oven-baked chips produced from GLB substituted whole wheat flour. Chips were produced from five formulations of whole wheat flour and 72 h germinated lima beans flour in the proportion 100:0%, 95:5%, 90:10%, 85:15% and 80:20% respectively. The *in-vitro* digestibility was conducted to determine the protein digestibility (PD), resistance starch (RS), rapidly digestible starch (RDS), slowly digestible starch (SDS), glycaemic index (GI), available carbohydrate (AC), starch digestibility (SD), and glycaemic load (GL). In addition, the amino acid composition which includes the non-essential and essential amino acid analyses were also carried out using standard procedures. The PD, RS and RDS of the composite chips significantly exceeded the control (100% whole wheat). The addition of GLB produced chips resulted in medium glycaemic index which ranged from 56.34- 65.06 compared with the whole wheat at 69.11. However, for the glycaemic load, intermediate glycaemic load of 18.69 and 17.17 were observed at 15% and 20% GLB substitution, respectively. The amino acids content was enhanced with the GLB substitution with marked increase in both the essential and non-essential amino acids of the chips. The nutritional and health potential of GLB incorporation in chips production is established and this can be utilized in diets for safe snacking.

Keywords: Legume, Whole grains, Composite flour, Amino acids

INTRODUCTION

Lima bean (*Phaseolus lunatus*) is a legume with common names such as butter beans, haba bean and burma bean (Featherstone et al., 2016) and locally in Nigeria, the Yoruba call it *papala* while it is called *wake rumpa* in Hausa (Ikani et al., 2017). Despite being affordable and nutritious, lima beans are underutilized and under-consumed. These flat or kidney-shaped legumes are rich in protein, low in fat, and packed with resistant starch and dietary fibre, making them an ideal food source to address malnutrition and enhance food security in developing countries (Ojo et al., 2024; Adebo, 2023; Ibeabuchi et al., 2019).

Utilization of legumes in food products is also driven by their health-promoting properties; however, this can be limited by the

antinutritional factors (ANFs) present in legumes. Aside this, legumes and their pulses display a high resistance to softening described as hard to cook (HTC) phenomenon which reduces their utilization as food (Pereira et al., 2023). To overcome this, bioprocessing method such as germination has been employed. Germination is an affordable and efficient method that enhances the nutritional and functional properties of flour (Yang et al., 2021).

During germination, changes in the endogenous nutritional components and interactions between the starch-protein components improves the digestibility and the

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protein amino acids profile (Zhang et al., 2025). Lately, the demand for consumption of sprouted pulses and its inclusion in the production of functional food products have significantly increased. According to Peñaranda et al. (2021), sprouted pulses and legumes are now a vital raw material in many ready to eat bakery products such as snacks.

Whole grains consumption has been recommended in many countries due to its proven ability to lower the risk of several health conditions (Wei et al., 2022; Oso and Ashafa, 2021), whereas refined flour-based food products have been linked with cardiovascular issues (Olagunju et al., 2021) digestive problems, nutritional deficiencies, and high glycaemic load and index making it unappealing to individuals with metabolic issues related to glucose and lipid levels (Amin et al., 2024).

Legume-cereal composite flour innovative approach has been encouraged because of the presence of lysine; an essential amino acid in legumes that is limiting amino acid in cereal grains (Boye et al., 2020). Whole wheat is a healthier choice and its consumption has been

METHODOLOGY

Procurement of Whole Wheat Grains and Lima Beans Seeds

The whole wheat grains (*Triticum aestivum*) and Lima beans (*Phaseolus lunatus*) seed (white variety) were purchased from a local market in Jos and Nasarawa State Nigeria respectively. Other ingredients such as margarine, table salt, baking powder for chips production were purchased from the local market in Minna Niger state.

Production of whole wheat flour and germinated white lima beans flour

Whole wheat grains (*Triticum aestivum*) were processed into flour according to the method described by Ojo et al. (2025). The whole wheat grains were manually sorted, ensuring that the extraneous materials were removed. This was followed by wet-cleaning, solar drying (10 h), milling (attrition mill), and sieving into aluminium bowl using a 100 µm

encouraged because it is a good source of dietary fibre, protein, essential minerals, vitamins, and plant-based compounds (Meenu et al., 2024). The inclusion of germinated lima beans to have a composite flour could further improve the amino acid composition.

Generally, chips are high calories product snacks produced from refined wheat flour and deep-fried which tends to increase the saturated fats (Gaytancıoğlu et al., 2024) making them unhealthy. This prompts the development of a more nutritious oven baked alternative. While legumes have been used in several studies (Espinosa-Ramírez et al., 2022; Sogunle et al., 2025; Amadi et al., 2025; Edima-Nyah et al., 2024) for snacks production, there is limited research on the impact on the in-vitro digestibility and amino acid content. It is therefore, hypothesise that oven-baked chips snacks produced from whole wheat and germinated white lima beans will be a healthier and nutritionally improved snack option characterized by low glycaemic index and load, high digestible protein with improved amino acid contents. This will support human overall health, create variety, increase the utilization of lima beans, thereby improving food security.

sieve. The whole wheat flour (WWF) was then packaged into a Ziploc bag till further use.

For the production of germinated white lima beans seeds flour, the Chinma et al. (2020) procedure was employed. Essentially, 2 kg of already sorted, wet-cleaned and dried white lima beans seeds were disinfected to suppress the mould growth by soaking in 1.20 litres of 1% food-grade sodium hypochlorite solution (Sigma Aldrich, Switzerland) for 30 min. Thereafter, the water was drained off and the bean seeds were further soaked in distilled water in ratio 1:3 for 10 h at room temperature while shaking every 1 h to ensure uniform hydration. The water was drained and hydrated beans were allowed to germinate in the dark and at ambient conditions of 28 ± 1 °C for 72 h being the optimum period for high nutritional potential of the Lima beans seeds for short term germination as reported by Amadeu et al. (2025) and Wu and Shin (2025). The germination process was terminated and the germinated seeds were picked out and solar dried using DEHYDROTRAY™ solar trays

for 12 h. The dried germinated beans flour (GLB) was produced by milling in a high-speed Kenwood blender (BLX750RD, Sheffield, UK), followed by sieving (100 µm mesh) to obtain the flour. This was packaged in an airtight plastic container with lid and stored at 4 °C until further use.

Production of whole wheat flour and germinated lima beans chips

Chips were prepared from the flour blends of the whole wheat and germinated lima beans flours were produced in the ratio 100:0 (WGA), 95:5 (WGB), 90:10 (WGC), 85:15 (WGD), and 80:20 (WGE). The flour blends were thoroughly blend and ships were produced following the procedure described by Chinma et al. (2020). Essentially 100 g of flour with 1 g of margarine, 3 g of baking powder, 1.2 g of table salt, and 32 ml water was mixed in a Kenwood FP190 Series mixer (Shenzhen, China) for 8 minutes. The dough was then rolled out using a pasta maker and cut into uniform squares measuring 2.0 x 2.0 cm arranged on the oven tray and baked at 190°C for 10 minutes in a Gallenkamp oven (Widnes, Cheshire, UK). After baking, the chips were left to cool for 20 min before being packaged. Chips produced from the whole wheat flour (WGA) served as the control.

Determination of *in-vitro* protein and starch digestibility

The In vitro protein digestibility (IVPD) was carried out using the protocol followed by Ojo et al. (2025). Twenty milligram (20 mg) of the samples each was accurately weighed and digested in 10 mL of trypsin (0.2 mg/mL in 100 mM Tris-HCl buffer, pH 7.6). Incubation of the suspension was done at 37°C for 2 h, and 5 mL of 50% trichloroacetic acid was added to end hydrolysis. The mixture was allowed to stand for 30 min, and using a centrifuge (Ostrode am Harz model 4515) at x4,000 for 15 mins. The recovered precipitate was dissolved in 5 mL of NaOH and protein concentration was determined using the micro-Kjeldahl method of AOAC (2005). Digestibility was calculated as:

$$\text{Protein digestibility} = \frac{\text{Digested protein}}{\text{Total protein}} \times 100 = \quad (1)$$

In-vitro starch digestibility and load

The standard method of AACC (2000) and Goñi et al. (1997) methods were employed for the In-vitro starch digestibility determination. Succinctly, the digestion kinetics non-linear model was used to assess the rapidly digestible starch (RDS) and slowly digestible starch (SDS) following incubation for 30 and further for 120 minutes, respectively. The glycaemic index and the glycaemic load of the chip samples was then calculated using the formula (2) and (3).

$$GI = \frac{iAUC \text{ test food}}{AUC \text{ glucose}} \times 100 \quad (2)$$

$$GL = \frac{GI \text{ of chips} \times \text{Available carbohydrates}}{100} \quad (3)$$

iAUC is the incremental area under the glucose response curve, GI = Glycaemic index, GL= Glycaemic load

Determination of amino acid composition

The method previously described by Chinma et al. (2015) was adopted for the determination of amino acid profiles of the chip samples. The samples (30 g) were finely crushed and hydrolysed with 6mol/l HCL at 116 °C for 24 h prior to analysis. After cooling and adjusting pH to 2.2 using NaOH, 0.5 ml of isoleucine was added as an internal standard. The sample was filtered through a 0.2 µm filter and 20 µl of the filtrate was analysed by high performance liquid chromatography (quasar, PerkinElmer, Hopkinton, USA) operating at 274 nm equipped with sodium oxidized column, cation exchange resin followed by post-column derivatisation of the amino acids to ninhydrin. The temperature was kept at 40 °C and the mobile phase was a mixture of chromatographic grade acetonitrile, methanol and acetic acid (10:40:50 ml/ml/ml). The tryptophan was determined in the known sample by hydrolyzing with 4.2 M Sodium hydroxide (Maria et al, 2004), dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loading into the amino acid analyzer.

RESULTS AND DISCUSSION

The *in vitro* digestibility of the whole wheat and germinated white lima bean chips differed across the chip samples. The evaluation of *in-vitro* starch and protein digestibility are vital in determining the nutritional quality of food (Jeong et al., 2019 and Shaghaghian et al., 2022). The *in-vitro* protein digestibility varied from 52.94 – 63.03% with percentage increase ranging between 1.66 – 19.05%. The *in-vitro* protein digestibility results in this study was higher than the values of Wabali et al. (2020) for wheat and African breadfruit seed biscuits at 25.73 – 47.33% and lower than the range 73.67 – 88.90% reported by Chinma et al. (2020) for germinated African yam bean substituted chips. The resistance starch (RS) and slowly digestible starch (SDS) increased up to 92%, 36% respectively at 20% GLB substitution (WGE) chips. On the other hand, the rapidly digestible starch (RDS), glycaemic

index (GI), available carbohydrate (AC), glycaemic index (GI) and starch digestibility (SD) decreased by 27%, 18.48%, 11.70%, 28.46% and 21.40% respectively. The RS could act as prebiotics and its effect in lowering glycaemic index and blood cholesterol has been reported (Dong et al., 2025). It was observed that the RDS was higher in the chips than the SDS. However, at 20% GLB substitution the difference was marginal, this implies that the chips glycaemic index will tends towards moderate at the range of 56-69 (measured against GI value of 100 using pure glucose as control). Similar result was reported by Chinma et al. (2021) in African yam beans substituted chips and Jiang et al. (2018) in protein-enriched sorghum chips. Also, Obadi et al. (2024) established cereal–legume blends.

Table 1. *In-vitro* digestibility & glycaemic load of germinated white lima beans flour substituted chips

| Parameters (%) | WGA | WGB | WGC | WGD | WGE |
|----------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| PD | 52.94 ^d ±0.00 | 53.82 ^b ±0.00 | 60.52 ^c ±0.00 | 60.59 ^c ±0.00 | 63.03 ^a ±0.00 |
| RS | 4.13 ^e ±0.00 | 4.90 ^d ±0.00 | 5.66 ^c ±0.00 | 6.63 ^b ±0.00 | 7.93 ^a ±0.00 |
| RDS | 36.20 ^a ±0.00 | 34.15 ^b ±0.01 | 31.41 ^c ±0.00 | 28.94 ^d ±0.01 | 26.44 ^e ±0.00 |
| SDS | 20.52 ^c ±0.00 | 22.84 ^d ±0.01 | 24.75 ^c ±0.00 | 26.35 ^b ±0.01 | 27.84 ^a ±0.00 |
| GI | 69.11 ^a ±0.00 | 65.06 ^b ±0.00 | 62.30 ^c ±0.00 | 59.44 ^d ±0.00 | 56.34 ^e ±0.01 |
| AC | 34.70 ^a ±0.09 | 33.28 ^b ±0.11 | 32.02 ^c ±0.02 | 31.47 ^d ±0.03 | 30.64 ^e ±0.17 |
| GL | 24.00 ^a ±0.06 | 21.61 ^b ±0.07 | 19.94 ^c ±0.01 | 18.69 ^d ±0.21 | 17.17 ^e ±0.10 |
| SD | 63.48 ^a ±0.01 | 60.01 ^b ±0.01 | 55.76 ^c ±0.01 | 52.94 ^d ±0.00 | 49.90 ^e ±0.00 |

Values are mean ± Standard error of triplicate determinations. Values in the same row with different superscripts are significantly different ($p \leq 0.05$). WGA=100% Whole wheat flour, WGB= 95% whole wheat flour 5% of germinated white lima beans flour WGC= 90% Whole wheat flour 10% of germinated white lima beans flour, WGD=85%Whole wheat flour 15% of germinated white lima beans flour and WGE =80% Whole wheat flour and 20% of germinated white lima beans flour. PD= Protein digestibility, RS= Resistance starch, RDS= Rapidly digestible starch, SDS= Slowly digestible starch, GI= Glycaemic index, AC= Available carbohydrate, GL= Glycaemic load SD= *In-vitro* starch digestibility.

and germinated flours produced lower GI foods due to their higher fibre, protein, and bioactive compounds. In addition, reduction of starch due to the dilution of whole wheat flour with the GLB flours and the shift in starch fractions during germination of the beans resulted in RDS reduction, increasing RS and SDS (Chinma et al., 2025) and this suggest their potential as functional snacks with positive health impacts (González et al., 2021).

The glycaemic load (GL) of foods gives a more useful information than using GI alone (Nednuri et al., 2025) because it takes into consideration both the GI and the actual quantity of carbohydrates in a normal serving. Food GL is a system of measurement used as a basis for weight loss, or diabetes control, and according to Eleazu (2016), GL is classified as

being low (< 10), intermediate (11–19) and high (> 20). The 10-20% GLB substituted chips showed an appreciable moderate GL value. The addition of GLB impacted significant changes in the starch fractions with enhanced *in-vitro* digestibility and consumption of the substituted chips could impart health positively. The substituted chips could be used as safe snacking diet plan for some persons who work towards diet change and/or patients attempting to lower their glycaemic load for healthier lifestyle.

Amino acid of whole wheat and germinated white lima bean-based chips

Table 2 and 3 shows the essential and non-essential amino acid content of chips produced from whole wheat and germinated white lima

beans composite flours respectively. Food protein quality is measured by the essential amino acid content provided in the diet (Damkat and Olumuyiwa, 2021). Higher concentration of essential amino acid content was observed in the germinated lima beans substituted chips, with exception of methionine which ranged from 1.12 to 1.26 g/100g protein at WGE and WGA chips samples respectively. This is expected as cereals contain higher amount of methionine while it is the first limiting amino acid in legumes. In this study, Leucine was the most

abundant while tryptophan was the most limiting at 6.42 (WGA) and - 7.69 g/100g (WGE) and 0.85 (WGA) – 1.18 g/100g protein (WGE) respectively. Leucine plays an important role in protein synthesis and repair of body tissues and generally, EAA deficient diet could lead to growth retardation, muscle mass loss, fatigue, and a weakened immune system (Xiao and Giuo, 2022). Similarly, Chinma et al. (2023) reported the highest values for leucine and methionine was the most limiting amino acids in germinated Bambara-nut composite bread.

Table 2. Essential amino acid of whole wheat and germinated white lima beans-based chips

| Parameters (g/100g protein) | WGA | WGB | WGC | WGD | WGE |
|--------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Leucine | 6.42 ^e ±0.01 | 6.71 ^d ±0.02 | 7.13 ^c ±0.01 | 7.38 ^b ±0.02 | 7.69 ^a ±0.00 |
| Lysine | 2.90 ^e ±0.50 | 3.42 ^d ±0.02 | 3.47 ^c ±0.06 | 3.60 ^b ±0.02 | 3.71 ^a ±0.02 |
| Isoleucine | 3.52 ^d ±0.04 | 3.63 ^c ±0.01 | 3.73 ^b ±0.05 | 3.75 ^b ±0.50 | 4.01 ^a ±0.02 |
| Phenylalanine | 4.04 ^e ±0.10 | 4.11 ^d ±0.03 | 4.15 ^c ±0.50 | 4.32 ^b ±0.03 | 4.71 ^a ±0.01 |
| Tryptophan | 0.85 ^e ±0.02 | 0.92 ^d ±0.01 | 1.04 ^c ±0.01 | 1.15 ^b ±0.01 | 1.18 ^a ±0.02 |
| Valine | 3.97 ^e ±0.06 | 4.23 ^d ±0.01 | 4.33 ^c ±0.02 | 4.50 ^b ±0.01 | 4.62 ^a ±0.26 |
| Methionine | 1.26 ^a ±0.01 | 1.24 ^b ±0.01 | 1.18 ^c ±0.03 | 1.12 ^e ±0.02 | 1.14 ^d ±0.10 |
| Histidine | 2.32 ^d ±0.01 | 2.31 ^d ±0.02 | 2.51 ^c ±0.02 | 2.84 ^b ±0.03 | 3.11 ^a ±0.05 |
| Threonine | 3.21 ^d ±0.03 | 3.12 ^e ±0.01 | 3.35 ^c ±0.02 | 3.42 ^b ±0.01 | 3.53 ^a ±0.01 |

Values are mean of replicate determination. Mean with different superscript in the same row are significantly different ($p \leq 0.05$), WGA=100% Whole wheat flour, WGB= 95% whole wheat flour 5% of germinated white lima beans flour WGC= 90% Whole wheat flour 10% of germinated white lima beans flour, WGD=85%Whole wheat flour 15% of germinated white lima beans flour and WGE =80% Whole wheat flour and 20% of germinated white lima beans flour.

Higher EAA in chips produced from germinated African yam beans- wheat composite flour than control (100% wheat) was reported by Chinma et al. (2021) Amongst the non-essential amino acids, glutamic acid is the most abundant followed by aspartic acid and arginine. Generally, the amino acids contents results obtained in the study are in

agreement with the report of Espinosa-Ramírez et al. (2022) and Chinma et al. (2023) on germinated legume composite flour baked products. The non-essential amino acids can be synthesized by the body. In some certain conditions such as injury, stress, and foetal development they become essential (Fayomi et al., 2025).

Table 3. Non-essential amino acid of whole-wheat and malted lima beans flour chips

| Parameters (g/100g protein) | WGA | WGB | WGC | WGD | WGE |
|--------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Proline | 4.22 ^a ±0.03 | 3.92 ^b ±0.03 | 3.43 ^d ±0.01 | 3.29 ^e ±0.04 | 3.50 ^c ±0.04 |
| Arginine | 4.43 ^e ±0.03 | 4.62 ^d ±0.01 | 4.81 ^c ±0.20 | 4.95 ^b ±0.12 | 5.31 ^a ±0.01 |
| Cysteine | 1.43 ^d ±0.02 | 1.45 ^d ±0.03 | 1.54 ^{bc} ±0.02 | 1.57 ^b ±0.03 | 1.61 ^a ±0.20 |
| Alanine | 3.60 ^c ±0.01 | 3.81 ^b ±0.03 | 3.50 ^d ±0.02 | 3.62 ^c ±0.01 | 4.07 ^a ±0.02 |
| Glutamic acid | 12.15 ^e ±0.02 | 12.34 ^d ±0.01 | 12.40 ^c ±0.01 | 12.62 ^b ±0.01 | 12.75 ^a ±0.03 |
| Glycine | 3.63 ^e ±0.02 | 3.72 ^d ±0.02 | 3.80 ^{bc} ±0.01 | 3.87 ^b ±0.25 | 4.16 ^a ±0.02 |
| Aspartic acid | 6.43 ^d ±0.02 | 6.62 ^{cd} ±0.02 | 6.74 ^{bc} ±0.04 | 6.86 ^b ±0.24 | 7.30 ^a ±0.01 |
| Tyrosine | 3.21 ^b ±0.12 | 3.23 ^b ±0.02 | 3.22 ^b ±0.02 | 3.40 ^a ±0.02 | 3.38 ^a ±0.02 |
| Serine | 3.80 ^b ±0.01 | 3.97 ^{ab} ±0.60 | 4.13 ^{ab} ±0.30 | 3.85 ^b ±0.51 | 4.31 ^a ±0.02 |

Values are mean of replicate determination. Mean with different superscript in the same row are significantly different ($p > 0.05$) while those with same superscript are not significantly different ($p > 0.05$). WGA=100% Whole wheat flour, WGB= 95% whole wheat flour 5% of germinated white lima beans flour WGC= 90% Whole wheat flour 10% of germinated white lima beans flour, WGD=85%Whole wheat flour 15% of germinated white lima beans flour and WGE =80% Whole wheat flour and 20% of germinated white lima beans flour.

Table 4 shows the calculated values for the amino groups present in the chips. Overall, 18.29% and 8.14% increase of total EAA and NEAA respectively was observed when compared with the control. Higher amount of NEAA than essential could be due to higher amount of NEAA in lima beans as reported by Damkat and Olumuyiwa (2021). Furthermore, the TAA improved by 12.19%. Overall, the GLB substituted chips exhibited higher amount of BCAAs, and acidic amino acids at percentage increase of 4.70-17.32% and 2.05-7.91% respectively. The BCAAs (branched chain amino acids) consists of leucine, isoleucine and valine, these amino acids enhance the generation of energy during a

protracted periods of exercise and regulates the glycaemic levels (Plotkin et al., 2021; Yamada et al., 2015). The Sulfur amino acid fluctuated between 2.69 and 2.70 g/100 g protein with marginal increase of 2.75 g/100g protein in sample WGE (20% GLB substitution). The acidic amino acid (glutamic and aspartic acids) contributes to the flavour-enhancing properties of foods which could impart the flavour of the chips and subsequent acceptance by consumers. Proteolytic hydrolysis of storage proteins during germination increased the free amino acids in the GLB as reported by Wu and Shin (2025) resulting in improved amino acid composition in the composite chips.

Table 4. Mean germinated lima beans substituted chips amino acid groups values (g/100g protein)

| Amino acid groups | WGA | WGB | WGC | WGD | WGE |
|-------------------|-------|-------|-------|-------|-------|
| TEAA | 28.49 | 29.69 | 30.89 | 32.08 | 33.70 |
| TNEAA | 42.90 | 43.68 | 43.57 | 44.03 | 46.39 |
| TAA | 71.39 | 73.37 | 74.46 | 76.11 | 80.09 |
| BCAA | 13.91 | 14.57 | 15.19 | 15.63 | 16.32 |
| Acidic AA | 18.58 | 18.96 | 19.14 | 19.48 | 20.05 |
| Sulfur AA | 2.69 | 2.69 | 2.70 | 2.70 | 2.75 |

WGA=100% Whole wheat flour, WGB= 95% whole wheat flour 5% of germinated white lima beans flour WGC= 90% Whole wheat flour 10% of germinated white lima beans flour, WGD=85%Whole wheat flour 15% of germinated white lima beans flour and WGE =80% Whole wheat flour and 20% of germinated white lima beans flour, TEAA =Total essential Amino acids, TNEAA= Total non-essential amino acid, TAA =Total amino acids (sum of essential and non-essential amino acids), BCAA= Branched chain amino acids (leucine +isoleucine+ valine), Acidic AA= Acidic amino acids (glutamic acid + aspartic acid) and Sulfur AA= Total Sulfur amino acids (methionine + cysteine).

CONCLUSION

The study suggests that the inclusion of germinated lima beans in chips production enhanced the in vitro protein digestibility improved by 19.05% while starch digestibility reduced up 21.40% in chips substituted with 20% germinated lima beans flour and lower glycaemic index and glycaemic load values was reported. The essential amino acids composition was enhanced with a marginal increase in Sulfur amino acids compared with the control chips. This highlights the ability of these substituted chips notably at 15-20% germinated lima beans substitution use as functional foods for blood sugar management and for general healthy snacking. However, further studies should be carried out on using in-vivo analysis to substantiate this impact on health.

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