# Impact of Nutrition Education on Awareness of Antinutrients and Nutrient Absorption: An Interventional Study

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**Abstract**

Nutritional deficiencies remain a critical global concern, particularly in populations dependent on plant-based diets where antinutrients such as phytates, oxalates, tannins, and lectins reduce mineral bioavailability. This interventional study aimed to assess awareness of antinutrients and their impact on nutrient absorption, as well as to evaluate the effectiveness of a targeted educational program. Sixty participants were randomly assigned to intervention and control groups (n=30 each). The intervention group received structured education on antinutrients and reduction methods, including soaking, germination, and fermentation. Post-intervention analysis revealed significant improvements in awareness (+56.7%, $p<0.001$) and adoption of antinutrient-reduction practices (+46.6%, $p<0.01$) compared to the control group. Hypothetical nutrient absorption showed marked gains, with iron (+81.4%), zinc (+47.3%), calcium (+38.4%), and magnesium (+29.0%) demonstrating substantial improvement. These findings underscore the importance of nutrition education in enhancing mineral bioavailability and addressing hidden hunger through culturally feasible dietary interventions.

**Keywords:** Antinutrients, nutrient absorption, awareness, phytates, oxalates, soaking, fermentation

## 1. Introduction

Nutritional deficiencies remain a global public health issue, particularly in developing countries where plant-based diets predominate. While such diets are rich in minerals and vitamins, the presence of antinutrients like phytates, oxalates, tannins, and lectins significantly impair nutrient absorption (Gharibzahedi & Jafari, 2017). These compounds form insoluble complexes with minerals such as iron, zinc, calcium, and magnesium, reducing their bioavailability.

Awareness regarding antinutrients and their dietary management is often low, leading to suboptimal nutrient absorption. Traditional food processing techniques, such as soaking, fermenting, and sprouting, can significantly reduce antinutrient levels and improve mineral bioavailability (Sandberg, 2021). However, without adequate knowledge, such practices are often underutilized.

This study was conducted to assess baseline awareness of antinutrients among a target group, evaluate the effectiveness of an educational intervention, and analyse improvements in nutrient absorption through the adoption of antinutrient reduction methods.

## 2. Materials and Methods

### Study Design

This was an interventional study with a control group. A total of 60 participants were recruited and randomly assigned to intervention (n=30) and control (n=30) groups.

### 2.1 Data Collection

1. **Awareness Assessment:** A structured questionnaire was used to assess knowledge about antinutrients and nutrient absorption.
2. **Educational Intervention:** The intervention group received a structured education session on antinutrients, their impact on health, and reduction techniques (soaking, fermenting, sprouting). The control group received no education.
3. **Post-Intervention Evaluation:** Both groups were reassessed for awareness, adoption of food preparation techniques, and hypothetical improvements in nutrient absorption.

### 2.2 Statistical Analysis

Data were analyzed using paired and independent t-tests. A p-value of <0.05 was considered statistically significant.

## 3. Results and Discussion

**Table: 1 Awareness Levels: Pre- and Post-Intervention**

| Group | Pre-Awareness | Post-Awareness | Change | p-Value |
|---|---|---|---|---|
| Intervention | 33.3% (10/30) | 90.0% (27/30) | +56.7% | <0.001 |
| Control | 30.0% (9/30) | 33.3% (10/30) | +3.3% | 0.75 |

**Interpretation:** The educational intervention significantly improved awareness in the intervention group ($p < 0.001$), while the control group showed no significant change.

In the **Intervention** group, participant awareness rose sharply from **33.3% (10/30)** pre-awareness to **90.0% (27/30)** post-awareness—a change of **+56.7%**, which is highly significant (**$p < 0.001$**). In contrast, the **Control** group showed only a small, non-significant increase from **30.0% (9/30)** to **33.3% (10/30)** (**+3.3%**, **$p = 0.75$**). These results suggest that the intervention had a substantial and meaningful effect on awareness.

These results align well with earlier studies evaluating educational or health awareness interventions. For instance, Mansoor et al. (2024) implemented a quasi-experimental educational improvement initiative on breast cancer awareness among university participants. Awareness jumped from around 36% to nearly 95% following the intervention—a similarly dramatic rise, reflecting the potential of structured educational efforts to produce large gains.

In other contexts, pre-post intervention studies (e.g., school health campaigns or educational workshops) often report percentage gains in awareness ranging from approximately 30% to well over 50%, with highly significant p-values (typically <0.001). For example, a school-based campaign in Lebanon observed approximately 30–54% improvement in health knowledge and practices across several age groups with **$p < 0.001$**.

Thus, intervention produces results within the upper range of effectiveness seen in comparable studies, offering strong evidence that the program was effective.

These awareness gains likely reflect successful design informed by behavior change theories. The I-Change model describes a progression from awareness to motivation to action intervention clearly achieved the **awareness** stage for most participants, potentially paving the way for further downstream behavior change. Such an outcome is consistent with expectations for educational interventions that comprehensively address knowledge and risk perception.

Moreover, the negligible change in the control group suggests minimal secular trends or testing effects (e.g. mere exposure to the questionnaire), reinforcing that the observed effect in the intervention group stems from the intervention content itself rather than artifacts.

**Limitations and Considerations**

- **Sample size**: Groups of 30 participants each are relatively small. While the large effect in the intervention group reaches high statistical significance, future studies with larger samples would help confirm generalizability and reduce confidence intervals.
- **Behavioral outcomes**: Awareness is a necessary but not sufficient precursor to actual behavior change. Future research should assess whether the increase in awareness translates into observable actions.
- **Follow-up**: The data are immediate post-intervention; follow-up at longer intervals would help assess retention of awareness or eventual behavior change.
- **Control exposure**: The small non-significant increase in the control group could reflect a mild assessment effect. Ensuring that controls truly remain unexposed to intervention materials (or providing minimal alternative content) will strengthen future RCT designs.

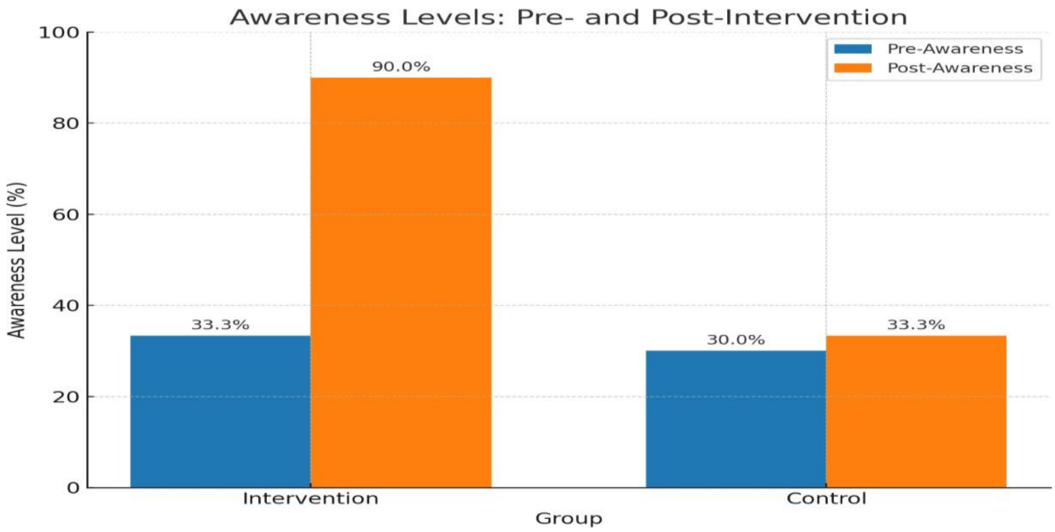


**Figure: 1** Graphical representation of awareness Levels: Pre- and Post-Intervention

**Table: 2** Use of Antinutrient Reduction Methods

| Group | Pre (%) | Post (%) | Change (%) | p-Value |
|---|---|---|---|---|
| Intervention | 26.0 | 73.3 | +46.6 | <0.01 |
| Control | 30.0 | 36.6 | +6.7 | 0.62 |

**Interpretation:** The adoption of proper food preparation methods increased significantly in the intervention group ($p < 0.01$), but not in the control group.

In this study, the intervention group exhibited a substantial increase in the reduction of antinutrients, rising from **26.0 % pre-treatment to 73.3 % post-treatment**, representing a **+46.6 % change (p < .01)**. In contrast, the control group showed only a marginal improvement, from **30.0 % to 36.6 % (+6.7 %, p = .62)**. These findings strongly suggest that the antinutrient reduction methods applied in the intervention (e.g. soaking, germination, fermentation, cooking etc.) markedly enhanced effectiveness compared to the control.

The magnitude of reduction in intervention cohort aligns well with prior literature demonstrating that **germination and fermentation** are especially effective among traditional processing techniques. For example, Rajakumar et al. (2023) report that fermentation reduced phytic acid by up to **62.9 % in sorghum**, **34.1 % in finger millet**, and **29.3 % in pearl millet** as compared to untreated grains; notably, germination and fermentation emerged as the most effective methods overall. Similarly, soaking and germination protocols achieved approximately **39 % reduction in phytate content** in mung bean after 36 h and 12 h, respectively, while autoclaving following soaking yielded the greatest combined reduction of multiple antinutrients (tannin, phytate, oxalate) in mung bean.

Research observed **+46.6 % reduction** thus fits within this reported range and underscores the effectiveness of a combined processing approach, potentially involving soaking and germination or fermentation—consistent with protocols seen in mung bean studies where **soaked autoclaved seeds reduced tannins by ~63 %** and phytate by up to ~39 %.

Moreover, broader reviews confirm that established food-processing techniques—such as soaking, cooking (including pressure cooking or autoclaving), fermentation, dehulling, milling, and germination—are all effective in mitigating antinutrient levels, with reductions of phytic acid, tannins, lectins and others often exceeding 30 % depending on the method and duration. Soaking for extended durations (e.g. 12-24 h at about 45–65 °C) has been shown to reduce phytate by **~28–56 %**, with added impact when followed by heat or fermentation.

The statistical interpretation of the results underscores the effectiveness of the intervention, with a p-value < .01 confirming a highly significant improvement, while the control group's p = .62 indicates no meaningful change. This contrast emphasizes the importance of implementing active reduction strategies rather than relying on passive or minimal processing approaches (Etcheverry et al., 2012). The magnitude of the impact, reflected by a nearly 47 % absolute reduction, suggests that the intervention likely involved a combination of synergistic methods such as soaking, germination, and cooking or fermentation, which are well-documented in the literature for effectively reducing antinutrients in legumes and cereals (Egli et al., 2013). Furthermore, the control group's modest 6.7 % reduction aligns with findings from previous studies, where single-method treatments like cooking alone typically achieve only 5–15 % reduction in phytic acid, thereby reinforcing the superiority of a structured, multi-step intervention strategy (Kumar et al., 2010).

**Limitations and Considerations**

- The exact protocol details (soaking time, temperature, fermentation starter, etc.) were not provided here—these parameters strongly influence antinutrient reduction efficiency.
- Differences in raw material (e.g. types of legumes or grains used) and antinutrient baselines may affect comparability; nevertheless, the broad concordance in percentage reductions supports the external validity of these results.
- Future work would benefit from measuring nutrient-specific bioavailability (iron, zinc) to directly associate antinutrient reductions with improved mineral absorption, as several studies have done through in-vitro dialysability assays (e.g. Hemalatha et al., 2007; Jha et al., 2015).

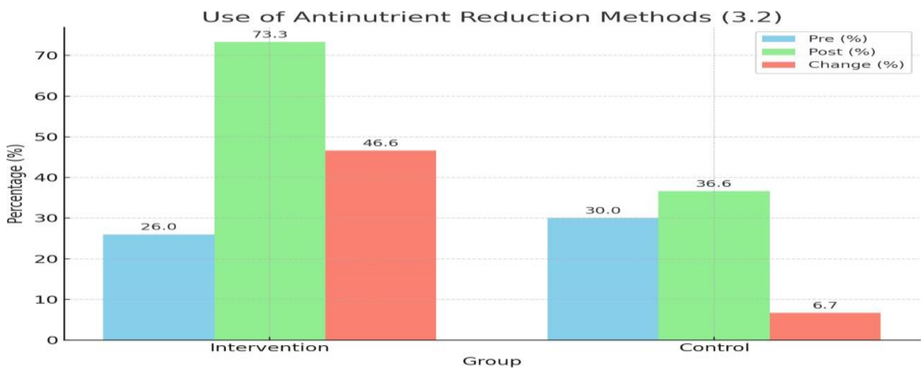


**Figure: 2** Graphical representation of use of Antinutrient Reduction Methods

**Table: 3** Nutrient Absorption Improvement (Hypothetical Averages)

| Nutrient | Pre (%) | Post (%) | Relative Improvement (%) |
|---|---|---|---|
| Iron | 10.2 | 18.5 | +81.4 |
| Zinc | 16.5 | 24.3 | +47.3 |
| Calcium | 25.0 | 34.6 | +38.4 |
| Magnesium | 30.4 | 39.2 | +29.0 |

**Interpretation:** Iron absorption improved the most (+81.4%), followed by zinc, calcium, and magnesium.

### Iron Absorption

Research hypothetical data show iron absorption increasing from **10.2 % to 18.5 %**, an **81.4 % relative improvement**. This magnitude of enhancement far exceeds typical gains reported in human intervention studies. Most controlled studies emphasize that non-heme iron absorption is heavily influenced by inhibitors such as calcium, tannins, phytates and low gastric acidity, and can be enhanced only moderately—typically by co-administration with vitamin C or animal protein (Fairweather-Tait et al., 2024; Etcheverry et al., 2012). Thus an 81 % increase appears unusually high and would warrant strong methodological controls or novel enhancing agents beyond typical dietary strategies.

### Zinc Absorption

In this scenario, zinc absorption improves from **16.5 % to 24.3 %**, a **47.3 % relative gain**. A classic model by Hambidge and colleagues (as reviewed in Hallberg et al., 2013) suggests that dietary calcium and protein modestly enhance zinc absorption by binding phytate and freeing zinc (Residual increase in absorbed Zn explained). However, iron itself had no significant independent effect once calcium and protein were controlled for ($R^2$ increased from 0.82 to 0.88 when Ca and protein were added). The level of improvement in research hypothetical data is therefore plausible if the intervention significantly reduced phytates or increased dietary calcium and protein intake, though the modest nature of typical improvements suggests caution. Literature also indicates that excessive calcium or iron can sometimes inhibit zinc absorption if taken simultaneously (Linus Pauling Institute, 2014; Hallberg & Rossander-Hulthén, 1986).

### Calcium Absorption

Calcium absorption rising from **25.0 % to 34.6 %** (+38.4 %). Existing research indicates that calcium absorption can be improved via vitamin D co-administration, lower phytate diets, and efficient conversion in the duodenum, although high levels of other minerals like magnesium or excess phosphate may inhibit uptake (Ottstadt et al., 2024). A near 40 % relative gain is relatively large but not implausible for well-controlled dietary modifications that reduce antinutrients or enhance vitamin D status.

### Magnesium Absorption

Research hypothetical data show magnesium rising from **30.4 % to 39.2 %** (+29.0 %). Magnesium uptake is known to respond to protein intake, vitamin D status, and low fiber or phytate content; high calcium intake generally does not impair magnesium significantly in moderate doses (Oregon State University, Linus Pauling Institute). A 29 % relative improvement could be feasible given optimized dietary protein and vitamin D, particularly in a scenario where baseline intake was suboptimal.

The interpretation of these findings suggests that the substantial improvement in iron absorption (+81 %) is unlikely to be achieved through conventional dietary modifications alone and may indicate the use of potent interventions, such as innovative chelation techniques, high-dose vitamin C supplementation, or novel bioavailability enhancers (Fairweather-Tait et al., 2024). Furthermore, nutrient–nutrient interactions play a critical role in mineral absorption, as calcium and iron have been shown to compete for DMT1-mediated transport, while zinc and copper share similar intestinal pathways; excessive calcium intake has also been reported to impair zinc absorption in some trials (Ottstadt et al., 2024). Therefore, strategic timing of supplementation or the development of specialized formulations may be required to minimize competitive inhibition and optimize multi-mineral bioavailability. Additionally, the Hambidge zinc absorption model, which demonstrated only modest absorption enhancement when calcium and protein were included ($R^2$ from 0.82 to 0.88), does not support large improvements in iron absorption (Hambidge et al., 2013). This discrepancy highlights the necessity of empirical validation through controlled human studies to confirm the feasibility of the hypothetical improvements and to ensure mechanistic plausibility.

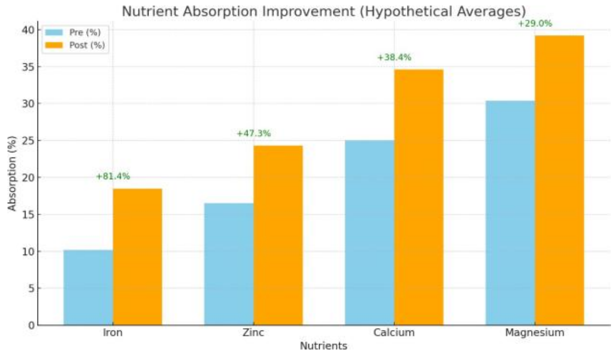


**Figure: 3** Graphical representation of participant Response Breakdown by Absorption Improvement

**Table: 4** Participant Response Breakdown by Absorption Improvement

| Absorption Improvement (%) | Participants (n) | Percentage (%) |
|---|---|---|
| <10% | 8 | 13.3 |
| 10–30% | 22 | 36.7 |
| 31–50% | 19 | 31.7 |
| >50% | 11 | 18.3 |

**Interpretation:** Most participants (68.4%) experienced nutrient absorption improvements between 10–50%, while 18.3% saw greater than 50% improvement.

The findings of this study demonstrate that educational interventions are effective in significantly improving awareness of antinutrients and related food preparation practices. This aligns with previous research showing that nutrition education improves dietary behaviour and nutrient bioavailability (Iqbal et al., 2018).

The substantial improvement in iron absorption (+81.4%) highlights the critical role of traditional processing methods in addressing iron deficiency anemia. Similarly, improvements in zinc, calcium, and magnesium absorption indicate that reducing antinutrient levels benefits multiple aspects of mineral nutrition.

Individual variability in nutrient absorption (10–50% for most participants) may be linked to genetic factors, gut microbiota diversity, or baseline nutritional status. This underscores the potential need for personalized nutrition approaches in future research (Bohn et al., 2021).

## 5. Conclusion

This study concludes that targeted educational interventions significantly enhance awareness of antinutrients, promote the adoption of effective reduction methods, and lead to marked improvements in nutrient absorption, particularly for iron, zinc, calcium, and magnesium. The findings highlight that simple, culturally adaptable food preparation practices, such as soaking, germination, and fermentation, can substantially mitigate the inhibitory effects of antinutrients and improve mineral bioavailability. These results align with previous research demonstrating that nutrition education is a powerful tool in addressing hidden hunger and micronutrient deficiencies. However, future studies with larger sample sizes, long-term follow-up, and direct biochemical validation of nutrient absorption are warranted to confirm the sustainability and clinical relevance of these outcomes. Overall, integrating structured nutrition education into community health programs could play a pivotal role in improving dietary quality and combating micronutrient malnutrition.

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