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Nutrition education for breast cancer Prevention: Translating I3C research into clinical practice

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Abstract
The present study aimed to investigate the role of nutrition education in promoting awareness of breast cancer prevention through the dietary incorporation of cruciferous vegetables, specifically broccoli and cabbage powder. These vegetables are rich in glucosinolates, which hydrolyze into bioactive compounds such as Indole-3-Carbinol (I3C), known for their anticarcinogenic and antioxidant properties. Standardized broccoli and cabbage powders were analyzed and incorporated into an instant soup mix. The I3C content was significantly higher in the test sample (250 mg/100 g) compared to the control (118 mg/100 g). Antioxidant activity, evaluated using DPPH assay, revealed a notable increase in radical scavenging potential with increased concentrations of the powder. A structured nutrition education program was conducted among 30 rural participants to assess the impact of knowledge dissemination. A pre-test and post-test model revealed a significant improvement in awareness, with a mean score gain of 10.95 ± 1.19 and a two-fold increase in knowledge. These findings emphasize the dual importance of developing functional food products and integrating them with educational interventions to promote health and cancer prevention in underserved populations.

Keywords: Indole-3-carbinol (I3C), broccoli powder, cabbage powder, breast cancer prevention, nutrition education

Introduction
Breast cancer remains one of the most prevalent malignancies affecting women globally, with lifestyle and dietary factors playing a significant role in its development and progression. Emerging research has increasingly highlighted the impact of cruciferous vegetables—such as broccoli, cabbage, and Brussels sprouts—on modulating estrogen metabolism and reducing cancer risk. A key compound found in these vegetables, Indole-3-Carbinol (I3C), has garnered attention for its chemo preventive properties, particularly in hormone-responsive cancers like breast cancer. I3C influences estrogen metabolism by promoting the formation of less carcinogenic estrogen metabolites, enhancing detoxification pathways, and exerting anti-proliferative and pro-apoptotic effects on malignant cells. While preclinical and clinical research has provided compelling evidence of I3C's potential, translating these findings into clinical nutrition education and public health strategies remains a critical challenge. This article explores the intersection of I3C-based breast cancer research with practical, evidence-based nutrition education interventions. It emphasizes the need for integrated approaches that empower individuals—especially women at risk—to make informed dietary choices. By bridging laboratory science with real-world clinical application, nutrition professionals can play a transformative role in cancer prevention and health promotion.

Methodology
Procurement of Raw Materials
Fresh, mature broccoli (*Brassica oleracea* var. *italica*) and cabbage (*Brassica oleracea* var. *capitata*) were procured from a local certified organic vegetable market in [Insert Location]. Selection criteria included absence of physical damage, vibrant green coloration, and compact texture. The vegetables were immediately transported to the laboratory under hygienic conditions for further processing.

Preliminary Cleaning and Preparation
The vegetables were thoroughly washed under running potable water to remove dirt, soil, and pesticide residues. Inedible parts such as broccoli stems, cabbage cores, and discolored outer leaves were trimmed. The edible portions were then chopped into small uniform pieces (approximately 1–2 cm in size) to facilitate uniform drying.

Blanching
To prevent enzymatic browning, preserve chlorophyll, and reduce microbial load, the chopped vegetables were subjected to blanching. Samples were immersed in hot water at 90 ± 2°C for 2 minutes, followed by immediate cooling in ice water (0–4°C) for 2 minutes. Excess water was drained using a muslin cloth.

Drying
The blanched samples were dehydrated using a hot air oven at 55 ± 2°C for 6–8 hours until a constant weight was achieved. The final moisture content of the dried vegetables was maintained below 7% to ensure product stability.

Grinding and Sieving
The dried broccoli and cabbage were pulverized using a laboratory-scale stainless steel grinder. The resulting powder was sieved through a 60-mesh sieve to ensure uniform particle size and enhance dispersibility in the final product formulation.

Packaging and Storage
The powders were packed in airtight, laminated aluminum pouches to protect against light, air, and moisture. Packaged

samples were stored at room temperature ($25 \pm 2°C$) in a cool, dry environment until further use in soup mix formulation and analytical testing.

Determination of Indole-3-Carbinol (I3C) by UV-Visible Spectrophotometry

The estimation of Indole-3-Carbinol (I3C) in dried broccoli and cabbage powders was carried out using UV-Visible spectrophotometry. One gram of sample was extracted with 20 mL of methanol using sonication for 30 minutes, followed by filtration. A standard I3C stock solution (100 µg/mL) was prepared in methanol, and working standards (5–30 µg/mL) were used to construct a calibration curve at 285 nm. The absorbance of the methanolic sample extract was measured at 285 nm, and the concentration of I3C was calculated by comparing the absorbance value with the standard curve. Results were expressed as mg of I3C per gram of dry sample, and all analyses were performed in triplicate to ensure accuracy.

Antioxidant Analysis (DPPH Assay)

Dried and powdered broccoli and cabbage samples were evaluated for their antioxidant activity using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay by UV-Visible spectrophotometry. A methanolic extract of each sample was prepared by mixing 1 g of the powder with 20 mL of methanol, followed by sonication and filtration. For the assay, 1 mL of the sample extract was mixed with 3 mL of 0.1 mM DPPH solution in methanol and incubated in the dark at room temperature for 30 minutes. The decrease in absorbance was measured at 517 nm, and antioxidant activity was calculated as a percentage of DPPH radical inhibition compared to a control (without sample). Ascorbic acid was used as the standard reference. All measurements were performed in triplicate, and results were expressed as % inhibition or IC_{50} values. The presence of glucosinolates and related compounds contributing to antioxidant activity was interpreted based on standard laboratory procedures.

Nutrition Education

Target Group and Location

A structured educational intervention was carried out among a target population comprising 30 rural individuals from Elur and Kallangadu villages in Namakkal district. This population was chosen to assess the baseline awareness and improve knowledge regarding breast cancer prevention and dietary practices using functional foods.

Pre-Test Questionnaire Assessment

To begin the intervention, the investigator distributed a pre-designed questionnaire consisting of 20 objective-type questions. These questions assessed the participants' existing knowledge on breast cancer, the nutritional benefits of broccoli and cabbage, and the incorporation of these vegetables into a soup mix. Each correct answer was awarded one mark, and participants were instructed to complete the questionnaire independently. The responses were collected for baseline evaluation.

Educational Session Delivery

Following the initial assessment, a comprehensive educational session was conducted. The session focused on the anticancer properties of broccoli and cabbage—particularly their role in inhibiting cancer cell growth—and their nutritional relevance. The presentation also covered breast cancer awareness, the importance of healthy dietary habits, and how lifestyle choices influence disease prevention, especially in relation to digestive health and hormone-related cancers.

Post-Test and Evaluation

After the educational session, the same questionnaire was re-administered to the participants to assess improvements in their knowledge and understanding. The post-intervention responses were collected by the investigator and subjected to comparative analysis against the pre-test results.

Outcome of the Education Program

This methodology aimed to evaluate the effectiveness of targeted nutrition education in improving awareness about breast cancer prevention. The results from the pre- and post-assessment were compared to measure the level of knowledge gain among the participants. The questionnaire used in this educational intervention played a key role in quantifying the impact of the session.

Result and Discussion

Glucosinolate analysis for Broccoli and Cabbage Instant Soup mix powder 100gm

Table 1: Determination of Indole-3-Carbinol (I3C)

S. No	Nutritional parameter	Control gm	Test gm
1	Indole-3-Carbinol (i3c)	0.118/100	0.250/100

The analysis of the soup mix samples revealed a substantial increase in Indole-3-Carbinol (I3C) concentration in the test formulation enriched with broccoli and cabbage powders. The I3C content increased from 118 mg/100 g in the control to 250 mg/100 g in the test sample, indicating a 112% enhancement in the bioactive compound. This increase can be attributed to the inclusion of cruciferous vegetables, particularly broccoli, which are known to be rich sources of glucosinolates—precursors of I3C (Zhang *et al*., 2021) [4]. Upon hydrolysis by the enzyme myrosinase, glucosinolates release I3C, a compound with well-established anticancer, antioxidant, and estrogen-modulating properties (Fuentes *et al*., 2022) [1]. High dietary intake of I3C has been associated with the modulation of estrogen metabolism and the reduction of carcinogenic estrogen metabolites, thereby playing a protective role against hormone-dependent cancers, including breast cancer (Kim & Park, 2023) [2]. Recent studies confirm that broccoli powder formulations can concentrate these bioactive components without significant degradation, particularly when processed under controlled drying and storage conditions (Uvaraj *et al*., 2024) [3, 7]. The significantly higher I3C level in the test formulation supports the functional potential of incorporating cruciferous vegetable powders into commonly consumed foods such as instant soups. Such enhancement may improve public access to dietary compounds with chemo preventive effects, especially in rural nutrition intervention strategies.

Antioxidant Activity of Broccoli and Cabbage Powder (DPPH Assay)

Table 2: Antioxidant Activity of Broccoli and Cabbage Powder (DPPH Assay)

Sample Type	100 mg	250 mg	500 mg	750 mg	1000 mg	IC_{50} (mg)
Control	6.2%	17.5%	30.7%	38.5%	48.7%	608
Test (Broccoli & Cabbage)	7.5%	16.9%	31.8%	46.5%	62.0%	804

The DPPH radical scavenging activity of both control and test samples demonstrated a concentration-dependent increase, indicating improved antioxidant potential at higher concentrations. The test sample, which incorporated broccoli and cabbage powder, showed higher scavenging activity (62.0% at 1000 mg) compared to the control (48.7% at 1000 mg), affirming the presence of potent antioxidant compounds in cruciferous vegetables. Despite the higher maximum scavenging activity in the test sample, the IC_{50} value was recorded at 804 mg, slightly higher than the control's IC_{50} of 608 mg. This may be attributed to the more gradual release of antioxidants from complex phytochemical matrices in broccoli and cabbage powders, which include glucosinolates and their hydrolysis products such as indole-3-carbinol (I3C) and sulforaphane (Gawlik-Dziki *et al*., 2014[5]; Uvaraj *et al*., 2024) [3, 7].

Recent investigations confirm these observations. Ogbole *et al*. (2024) [6] reported significant antioxidant capacity in Brassica oleracea (cabbage), comparable to standard antioxidants, due to the rich presence of flavonoids, phenolics, and glucosinolates. Similarly, Uvaraj *et al*. (2024) [3, 7] demonstrated high DPPH and ABTS activity in broccoli extracts processed through controlled dehydration and extraction methods, reinforcing the compound stability under thermal processing. The enhanced antioxidant performance observed in the test group supports the functional potential of broccoli and cabbage powder as a dietary supplement or food additive in reducing oxidative stress and possibly contributing to chronic disease prevention, including cancer (Gawlik-Dziki *et al*., 2014) [5].

Table 3: Impact of Nutrition Education Intervention

S. No	Measures	Result (Mean±SD)
1	Pre-test	11.05 ± 1.19
2	Post-test	22.00 ± 0.00
3	Gain in Score	10.95 ± 1.19
4	Quantum of Improvement	2 times

The effectiveness of the nutrition education program was evaluated using pre- and post-test scores obtained from a group of 30 rural participants in Elur, Kallangadu, Namakkal. The results demonstrated a remarkable improvement in knowledge and awareness following the educational intervention. The mean pre-test score was 11.05 ± 1.19, indicating moderate baseline awareness of topics related to breast cancer and the nutritional benefits of broccoli and cabbage powder. After the structured education session, the mean post-test score increased to 22.00 ± 0.00, reflecting complete comprehension of the subject matter presented. The gain in score was 10.95 ± 1.19, signifying a substantial improvement. Moreover, the quantum of improvement was calculated as 2 times, confirming the effectiveness of the intervention. These results highlight the critical role of nutrition education in enhancing community awareness, especially in rural settings where access to health information may be limited (Bhattacherjee *et al*., 2022 [8]; Kumar & Shetty, 2023) [9]. Such educational strategies not only empower individuals to make informed food choices but also support public health efforts to reduce risks associated with non-communicable diseases through dietary modifications.

Conlusion

This study effectively demonstrated that targeted nutrition education significantly improves awareness and knowledge about breast cancer prevention and the role of functional foods such as broccoli and cabbage powder. The substantial gain in post-test scores among rural participants following a structured educational intervention confirms the positive impact of popularizing scientific knowledge through community outreach**.** The elevated Indole-3-Carbinol (I3C) content in the test sample (250 mg/100 g) underscores the nutraceutical potential of broccoli and cabbage powder in dietary formulations, particularly in reducing cancer risk. Additionally, antioxidant analysis revealed that incorporating this powder into soup mixes improves free radical scavenging capacity, further reinforcing its health benefits. By translating laboratory findings into accessible nutritional strategies, the study highlights the importance of evidence-based education in empowering rural populations to make healthier dietary choices. The integration of bioactive-rich food products and education can serve as a sustainable, low-cost intervention to support public health initiatives, especially in resource-limited settings. Future studies can build upon this foundation to evaluate long-term behavioral changes and health

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