**Original Research Article**

# Unused portions of vegetables can void malnutrition: Production, acceptability, and nutritional analysis

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***Abstract:*** Nutritional deficiency is a serious public health concern in many developing nations due to the high cost of food for those in lower socioeconomic classes. A total of 1.3 billion tons of food are reportedly lost or wasted annually, beginning in the production phase and continuing into the consumer sector. Yet, worldwide, malnutrition-related problems claim the lives of 75% of youngsters. In Asia, including India, cauliflower, turnips, radishes, and peas are frequently consumed and grown in enormous amounts. However, the leaves and pods of these vegetables are normally discarded. They include large macronutrients, vitamins, minerals, and antioxidant-rich phenolic chemicals. In this study, unwanted vegetable parts—primarily leaves and pods—typically thrown away in trash cans were repurposed to create a product that can help the low-socioeconomic population overcome nutritional deficiencies. The product variations were made using unused turnips, radish, pea pods, and cauliflower leaves. The items with the best acceptability were those that were high in calcium, iron, vitamin A, vitamin C, phenol, and antioxidants. Therefore, it can be stated that the developed product variations, which were created utilizing an abandoned vegetable portion (leaves and pods), are nutrient-dense, affordable, and capable of addressing nutritional inadequacies.

***Keywords:*** malnutrition; micronutrient deficiency; phenolic compound; antioxidant property

## 1. Introduction

In India, 195.9 million people were chronically malnourished or underweight between 2015–2017, down from 204.1 million between 2005–2007. This is according to data from the Food and Agriculture Organization (FAO) of the United Nations. Economic disparity is one of the main factors contributing to malnutrition in India. Some demographic groups have poor social standing, causing a lack of quality and quantity in their diets. India is currently experiencing a severe malnutrition issue, as it accounts for about a third of the world's stunting cases, according to a worldwide nutrition report released in 2018. Although India has made progress in lowering child stunting, the country still has the greatest percentage of stunted children under five, at 46.6 million[1,2].

Green leafy vegetables are the least expensive and most abundant sources of phenolic compounds, which include phenols, flavonoids, alkaloids, tannins, terpenoids, coumarins, and glucosinolates, as well as vitamins (such as carotene, ascorbic acid, riboflavin, and folic acid) and minerals (such as iron, calcium, and phosphorous)[1,2]. To address these nutritional inadequacies, nutritionists are advising both rural and urban populations to include green leafy vegetables in their diets. Food security is the primary cause of macro- and micronutrient deficiencies in poor nations; however, every year, 1.3 billion tons of food are lost or wasted from the production stage to the consumer domain[1–4]. The vegetable processing industry produces more than one million tons of trimmings and unused portions of vegetables, and these materials can add value to the many children, women, and elderly people of low socioeconomic status who are suffering from nutritional deficiencies as a result of a poor diet and poor health[5–9].

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According to research data, radish leaves are a rich source of vitamins C, A, and B6. Radish leaves also contain a considerable amount of minerals, such as potassium, magnesium, calcium, and iron[10]. The leaves of cauliflower are a significant source of fiber and vitamin C. Cauliflower leaves are also a source of selenium, which works with vitamin C to strengthen the immune system, along with a significant quantity of vitamin A, folate, calcium, and potassium[5,11]. Pea pods are a good source of minerals, such as potassium, phosphorus, magnesium, and calcium, as well as vitamin A, vitamin C, and crude protein[12]. The purpose of the study was to create a low-cost nutritious dish using unused vegetable parts (green leafy portions of cauliflower, radish, turnips, and pea pods).

# 2. Materials and methods

## 2.1. Materials

A sample collection of fresh ingredients (potatoes, cauliflower leaves, radish leaves, turnip leaves, pea pods) were collected from a local market in Kolkata, India. The peels and leaves were finely chopped, sautéed, and utilized for the developed products.

The reagents required were anthrone reagent, bovine serum albumin (BSA), petroleum ether, biuret reagent, 2,6-dichloro indophenol dye, metaphosphoric acid, Folin-Ciocalteu reagent, and DPPH (2,2-diphenyl-1-picrylhydrazyl) reagent obtained from Merck, India.

## 2.2. Product development

The Aloo Tikki (potato croquettes from the Indian subcontinent) was chosen as the basic product. The recipe and ingredients are presented in **Table 1**. To make the Aloo Tikki, the potatoes were washed and then boiled under pressure. The potatoes were then peeled and mashed with a masher. Spices were added and mixed with salt. The mixture was divided into small, equal parts and shaped into small balls. The balls were sprinkled with refined wheat flour. Then oil was heated in a non-stick pan and the balls were fried till they became golden and crisp, and they were served hot.

**Table 1.** Ingredients of basic product (Aloo Tikki, potato croquettes from Indian subcontinent).

| Ingredient | Amount |
|---|---|
| Potato | 100 gm |
| Red chili powder | 1.25 gm |
| Whole wheat flour | 15 gm |
| Oil | 2.5 mL |
| Salt | 5 gm |

Different variations were made by incorporating different unused portions of vegetables with varying amounts (10 g, 20 g, and 30 g) individually as well as in various combinations, into the standard recipe of the Aloo Tikki (see **Table 2**).

**Table 2.** Different variations (by addition or replacement of ingredients) of Aloo Tikki.

| Variation | Description of variation |
|---|---|
| 1a | 10 gm cauliflower leaves + basic recipe |
| 1b | 20 gm cauliflower leaves + basic recipe |
| 1c | 30 gm cauliflower leaves + basic recipe |
| 2a | 10 gm radish leaves + basic recipe |
| 2b | 20 gm radish leaves + basic recipe |

**Table 2.** (*Continued*).

| Variation | Description of variation |
|---|---|
| 2c | 30 gm radish leaves + basic recipe |
| 3a | 10 gm turnip leaves + basic recipe |
| 3b | 20 gm turnip leaves + basic recipe |
| 3c | 30 gm turnip leaves + basic recipe |
| 4a | 10 gm pea pods + basic recipe |
| 4b | 20 gm pea pods + basic recipe |
| 4c | 30 gm pea pods + basic recipe |
| 5a | 2 gm radish leaves + 2 gm cauliflower leaves + 2 gm turnip leaves + 2 gm pea pods + basic recipe |
| 5b | 4 gm radish leaves+ 4 gm cauliflower leaves+ 4 gm turnip leaves + 4 gm pea pods + basic recipe |
| 5c | 6 gm radish leaves + 6 gm cauliflower leaves + 6 gm turnip leaves+ 6 gm pea pods + basic recipe |
| 6a | 2 gm radish leaves 2 + gm cauliflower leaves + 2 gm turnip leaves + 2 gm pea pods + basic recipe (15 gm sattu (gram powder) replacing 15 gm whole wheat flour) |
| 6b | 4 gm radish leaves + 4 gm cauliflower leaves + 4 gm turnip leaves + 4 gm pea pods + basic recipe (15 gm sattu (gram powder) replacing 15 gm whole wheat flour” |
| 6c | 6 gm radish leaves + 6 gm cauliflower leaves + 6 gm turnip leaves + 6 gm pea pods + basic recipe (15 gm sattu (gram powder) replacing 15 gm whole wheat flour) |

## 2.3. Sensory evaluation

A panel of 20 members (made up of community members) evaluated the standard product and all modifications organoleptically for various quality aspects (color, appearance, texture, taste, and odor) and overall acceptability using a 9-point hedonic scale.

## 2.4. Chemical analysis

Chemical analyses were performed on the basic product and the strongly approved product variations (selected by panel members) to determine the amount of carbohydrates, protein, fat, calcium, iron, beta-carotene, vitamin C, phenol, and DPPH radical scavenging activity.

### 2.4.1. Estimation of macronutrient level

The product variations’ protein content was calculated using the Biuret method[13]. The Soxhlet method was used to calculate the fat content[14]. The anthrone method was used to assess the total carbohydrate content[15].

### 2.4.2. Estimation of calcium and iron content

The estimation of iron and calcium was done using a kit (Coral Clinical System, India).

### 2.4.3. Estimation of beta-carotene and ascorbic acid level

The product variations’ ascorbic acid content was estimated using the indophenol dye method[16]. Beta-carotene was estimated based on Karnjanawipagul et al.[17].

### 2.4.4. Estimation of total phenol

The Folin-Ciocalteu method was used to calculate the total phenolic content. In an alkaline medium, the Folin-Ciocalteu reagent reacts with phenolic chemicals to produce a blue chromophore made of a phosphotungstic/phosphomolybdenum complex that absorbs light and enables measurement. Results were given in milligrams of gallic acid equivalents (GAE) per 100 g of fresh weight[18].

### 2.4.5. Estimation of free radical scavenging activity

An ethanol solution of 0.4 mM DPPH was made. A test sample of 3 mL was combined with 1 ml of the DPPH solution. A control was created by mixing 3 mL of ethanol with 1 mL of the DPPH solution. A spectrophotometer was used to test the mixture's absorbance at 517 nm after it was rapidly mixed and left to remain at room temperature for 30 min[19].

## 2.5. Statistical analysis

While the average sensory scores for each attribute were based on 20 evaluations, the results of the chemical analysis were given as the mean ± standard deviation of triplicate analyses. The panelists-approved product variations underwent chemical analysis to determine the product variations' levels of carbohydrates, protein, fat, calcium, iron, beta-carotene, vitamin C, phenol, and free radical scavenging action.

# 3. Result and discussion

## 3.1. Sensory evaluation

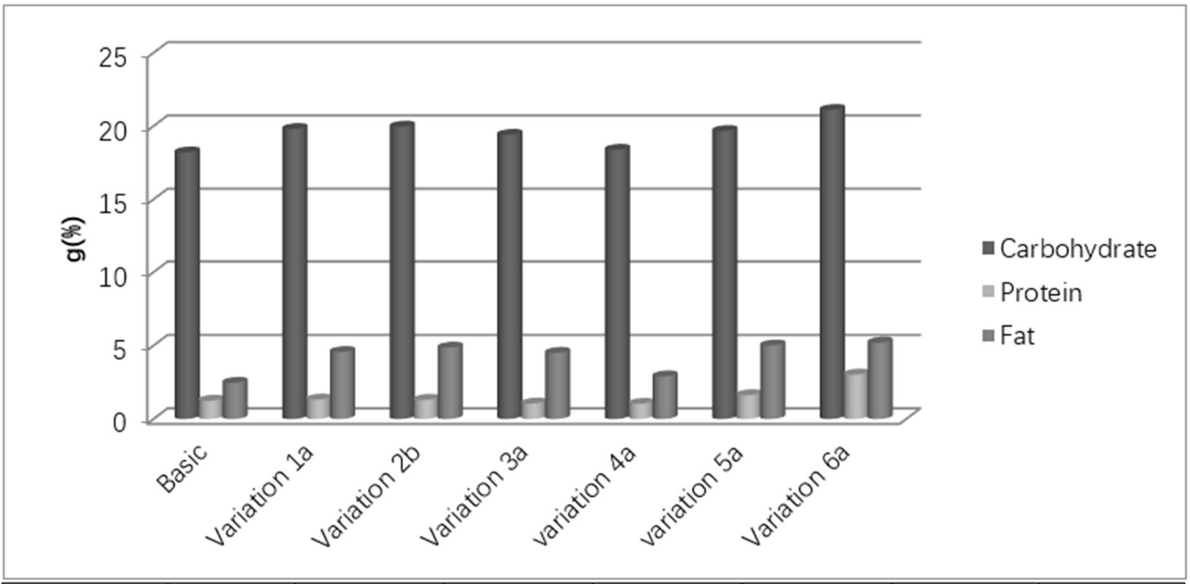
During the sensory evaluation and comparative study of the product variations, the acceptability of the product variations, as well as the basic product, was assessed using ratings acquired through a scorecard utilizing a 9-point hedonic scale (appearance, taste, texture, color, and overall rating). The different combinations were made to increase the organoleptic properties as well as the acceptability of the product variations. At the same time, the different combinations made the nutrition profile of the product variations better. From the overall rating, the most popular product variations from each group and the basic product were chosen for biochemical investigation (see **Table 3**). Variation 1a, Variation 2b, Variation 3a, Variation 4a, Variation 5a, and Variation 6a were the selected variations (see **Table 3**).

**Table 3.** Mean ± standard deviation of scores given to various sensory evaluation aspects.

| Variation | Appearance | Color | Aroma | Texture | Taste | Rating (overall) |
|---|---|---|---|---|---|---|
| Recipe (basic) | 9.0 ± 0.27 | 8.9 ± 0.47 | 8.8 ± 0.37 | 8.7 ± 0.51 | 8.8 ± 0.45 | 8.8 ± 0.44 |
| 1a | 9.0 ± 0.37 | 8.8 ± 0.37 | 8.9 ± 0.37 | 9.0 ± 0.37 | 8.8 ± 0.37 | 8.9 ± 0.38 |
| 1b | 8.6 ± 0.59 | 8.8 ± 0.49 | 8.5 ± 0.61 | 8.7 ±0.51 | 8.4 ± 0.49 | 8.4 ± 0.50 |
| 1c | 8.5 ± 0.49 | 8.4 ± 0.51 | 8.5 ± 0.49 | 8.2 ± 0.47 | 8.4 ± 0.50 | 8.2 ± 0.43 |
| 2a | 8.5 ± 0.49 | 8.7 ± 0.41 | 8.2 ± 0.47 | 8.7 ± 0.52 | 8.3 ± 0.46 | 8.3 ± 0.45 |
| 2b | 8.4 ± 0.51 | 8.8 ± 0.32 | 8.5 ± 0.51 | 8.4 ± 0.47 | 8.7 ± 0.46 | 8.5 ± 0.52 |
| 2c | 8.6 ± 0.51 | 8.4 ± 0.52 | 8.6 ± 0.51 | 8.5 ± 0.50 | 8.6 ± 0.52 | 8.7 ± 0.50 |
| 3a | 9.0 ± 0.37 | 8.9 ± 0.38 | 8.7 ± 0.42 | 8.6 ± 0.68 | 8.8 ± 0.37 | 8.7 ± 0.48 |
| 3b | 8.9 ± 0.36 | 8.7 ± 0.41 | 8.7 ± 0.50 | 8.3 ± 0.51 | 8.5 ± 0.50 | 8.6 ± 0.47 |
| 3c | 8.7 ± 0.51 | 8.5 ± 0.60 | 8.6 ± 0.61 | 8.4 ± 0.68 | 8.5 ± 0.68 | 8.5 ± 0.62 |
| 4a | 8.6 ± 0.51 | 8.4 ± 0.52 | 8.2 ± 0.85 | 8.3 ± 0.52 | 8.2 ±0.38 | 8.4 ± 0.51 |
| 4b | 8.4 ± 0.51 | 8.6 ± 0.52 | 8.4 ± 0.64 | 8.5 ± 0.52 | 8.3 ± 0.60 | 8.2 ± 0.60 |
| 4c | 7.8 ± 0.59 | 8.2 ± 0.31 | 7.6 ± 0.93 | 7.2 ± 0.47 | 7.3 ± 0.70 | 7.7 ± 0.48 |
| 5a | 8.9 ± 0.31 | 9.0 ± 0.31 | 8.9 ± 0.40 | 8.7 ± 0.41 | 8.7 ± 0.43 | 8.7 ± 0.48 |
| 5b | 8.3 ± 0.60 | 8.6 ± 0.51 | 8.2 ± 0.57 | 8.7 ± 0.50 | 8.6 ± 0.52 | 8.6 ± 0.53 |
| 5c | 8.3 ± 0.37 | 8.1 ± 0.37 | 8.5 ± 0.68 | 8.1 ± 0.62 | 8.2 ± 0.64 | 7.8 ± 0.43 |
| 6a | 9.0 ± 0.37 | 8.8 ± 0.37 | 8.8 ± 0.37 | 8.9 ± 0.41 | 8.8 ± 0.42 | 8.9 ± 0.32 |
| 6b | 8.4 ± 0.47 | 8.2 ± 0.47 | 8.7 ± 0.50 | 8.5 ± 0.50 | 8.7 ± 0.49 | 8.7 ± 0.49 |
| 6c | 8.2 ± 0.49 | 8.1 ± 0.41 | 8.0 ± 0.55 | 8.2 ± 0.55 | 8.3 ± 0.45 | 8.4 ± 0.47 |

## 3.2. Total macronutrient level

The amounts of protein, fat, and carbohydrates in the most popular product variations, as well as in the basic product, were estimated. It was discovered that the protein and carbohydrate composition of the basic product and the most popular product variations did not differ significantly. Only Variation 6a showed a higher protein content, as the wheat flour was replaced with sattu (gram powder). However, the fat contents were slightly higher in the most popular product variations compared with that in the basic product, as the added leaves were sautéed (see **Figure 1**).




| g(%) | Basic | Variation 1a | Variation 2b | Variation 3a | variation 4a | variation 5a | Variation 6a |
|---|---|---|---|---|---|---|---|
| Carbohydrate | 18.2 ± 2.5 | 19.8 ± 2.7 | 19.96 ± 2.9 | 19.4 ± 2.5 | 18.38 ± 2.3 | 19.6 ± 3.1 | 21.1 ± 2.9 |
| Protein | 1.24 ± 0.5 | 1.32 ± 0.2 | 1.3 ± 0.7 | 1.05 ± 0.6 | 1.03 ± 0.9 | 1.62 ± 1.2 | 3.02 ± 1.1 |
| Fat | 2.46 ± 0.2 | 4.56 ± 0.3 | 4.86 ± 0.9 | 4.5 ± 1.0 | 2.9 ± 0.7 | 5.1 ± 1.2 | 5.2 ± 1.1 |

**Figure 1.** Macronutrient (protein, carbohydrate and fat) levels of basic product and the most accepted variations.

## 3.3. Estimation of beta-carotene and ascorbic acid

It was found that the beta-carotene (vitamin A) and ascorbic acid (vitamin C) contents were much higher in the developed product variations compared with those in the basic product. In the case of the developed product variations, Variation 2b (made with radish leaves) showed the highest beta-carotene and ascorbic acid content, whereas Variation 4a (made with pea pods) showed the lowest values (see **Figure 2**). The human body converts beta-carotene into vitamin A (retinol). Like all carotenoids, beta-carotene is an antioxidant. An antioxidant is anything that prevents other molecules from being oxidized, shielding the body against free radicals. Cells are harmed by free radicals due to oxidation. Free-radical damage can eventually result in a number of chronic disorders. Numerous studies have demonstrated how consuming antioxidants in the diet strengthens the immune systems of individuals, guards against free radicals, and reduces the risk of heart disease and cancer. All bodily tissues need vitamin C, commonly known as ascorbic acid, to grow, develop, and heal. Vitamin C contributes to a variety of bodily processes, including collagen synthesis, iron absorption, immunological function, wound healing, and cartilage, bone, and skin safeguarding[20].

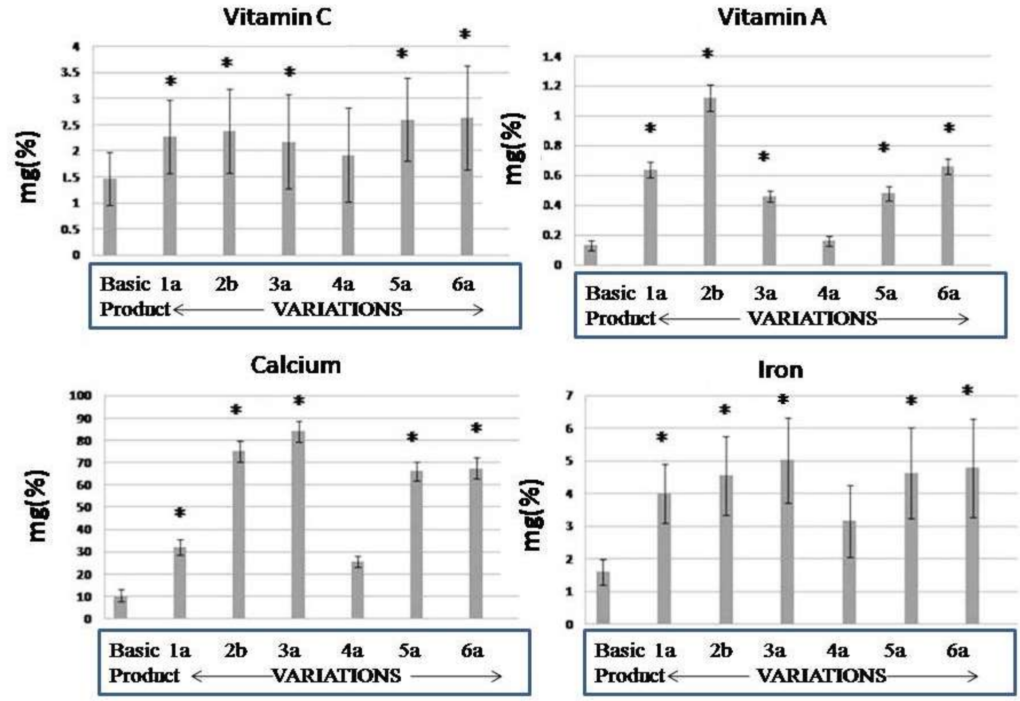



**Figure 2.** Amounts of vitamin A, vitamin C, calcium, and iron in basic product and the most accepted variations.
Note: Values are mean ± SD. * $P < 0.05$ vs. basic product.

### 3.4. Estimation of calcium and iron

It was found that the calcium and iron contents were much higher in the developed product variations compared with those in the basic product. In the case of the developed product variations, Variation 3a (made with turnip leaves) showed the highest calcium and iron contents, whereas Variation 4a (made with pea pods) showed the lowest values (see **Figure 2**). It is now understood that calcium, a dietary mineral, contributes to numerous vital bodily processes on a daily basis. Its impact on muscle contractions, which in turn help control the heartbeat and aid in nerve impulse transmission, is one of its most crucial functions. Additionally, calcium has been discovered to be a crucial element in effective blood clotting, preserving blood vessel walls, and activating particular enzymes. Iron is an essential element for the human body. Hemoglobin, a protein present in red blood cells, contains more than 65% of the body's iron. The central atom of this heme molecule is iron, which functions to transport oxygen molecules to all cells in the human body. Iron participates in the electron transport chain, which assists in energy production and helps tissues store oxygen. Iron also participates in a number of enzymatic processes that the body needs on a regular basis[21].

### 3.5. Estimation of total polyphenol

Due to their antioxidant qualities, polyphenols, which are secondary metabolites present in plants, are extremely beneficial for human health. The long-term consumption of a diet high in polyphenols may provide protection against the development of cancer, cardiovascular disease, diabetes, osteoporosis, and neurological illness, according to epidemiological studies and related meta-analyses by Karnjanawipagul et al.[17].

It was found that the total polyphenol contents were much higher in the developed product variations compared with that in the basic product. In the case of the developed product variations, the total polyphenol contents were found to be the highest in Variation 2b (made with reddish leaves) and the lowest in Variation 4a (made with pea pods) (see **Table 4**). The bioactivity of polyphenols may be related to their antioxidant behavior, which is explained by their ability to chelate metals, inhibit lipoxygenase, and scavenge free radicals[22].

**Table 4.** Free radical scavenging property and phenol content of the most accepted product variations.

| | Basic product | Variation 1a | Variation 2b | Variation 3a | Variation 4a | Variation 5a | Variation 6a |
|---|---|---|---|---|---|---|---|
| Phenol (mgGAE/100 gm) | 83 ± 4.5 | 104 ± 5.7* | 118 ± 6.2* | 106 ± 5.3* | 100 ± 4.9 | 109 ± 5.2* | 110 ± 5.5* |
| DPPH free radical scavenging property (%) | 29.7 ± 3.5 | 47.7 ± 4.7* | 51.7 ± 4.9* | 41.3 ± 5.3* | 30.5 ± 4.2 | 54.1 ± 5.7* | 57.1 ± 5.1* |

Note: Values are mean ± SD. *: $P < 0.05$ vs. basic product.

### 3.6. Estimation of anti-oxidant/free radical scavenging property

To analyze the anti-oxidant property, the DPPH free radical scavenging activity of the products was estimated. It was found that the free radical scavenging property was much higher in the developed product variations compared with that in the basic product. In the case of the developed product variations, the free radical scavenging properties were found to be the highest in Variation 2b (made with reddish leaves) and the lowest in Variation 4a (made with pea pods) (see **Table 4**). An antioxidant-rich diet may lower the risk of numerous illnesses, including heart disease and several types of cancer. Antioxidants remove free radicals from bodily cells, preventing or lessening oxidative damage[23].

From the chemical analysis, it is observed that the developed product variations were rich in vitamin C, vitamin A, and phenol content and also exhibited higher DPPH free radical scavenging activities. Reactive oxygen and nitrogen species, which can cause oxidative damage to macromolecules, such as lipids, DNA, and proteins, and are linked to chronic diseases, such as cardiovascular disease, stroke, cancer, and neurodegenerative diseases, are significantly reduced by vitamin C, an important dietary antioxidant[23].

Vitamin A also acts as an antioxidant by quenching singlet molecular oxygen and scavenging reactive oxygen species, especially peroxyl radicals[24]. Phenolics have the ability to scavenge free radicals, chelate metal catalysts, activate antioxidant enzymes, and inhibit oxidases. This ability makes them useful in the treatment of degenerative disorders, including diabetes and hypertension. The increased DPPH scavenging activities indicated higher antioxidant activities of the products made from unused portions of vegetables.

## 4. Conclusion

In conclusion, malnutrition, the underlying cause of many other ailments, is dangerously rising in developing countries. Malnutrition should not only be treated pharmaceutically but also with dietary changes. This project sought to eradicate malnutrition in low-socioeconomic population by using unused portions of vegetables. Vegetable pomace, peels, and seeds are wasted despite the fact that they contain many minerals and antioxidants that are important in avoiding many diseases caused by micronutrient deficiencies. In this present investigation, products were developed using unused portions of vegetables, and the study found that the developed product variations were not only nutrient-rich but also rich in polyphenol and antioxidants. In order for people with a low-socioeconomic status to live a healthy life, it is advantageous to incorporate all of these nutrient-rich wastes into their diet.

## Author contributions

Conceptualization, MD; methodology, BR; software, BR; validation, MD; formal analysis, BR; investigation, MD; resources, MD; data curation, BR; writing—original draft preparation, MD; writing—review and editing, MD; visualization, MD; supervision, MD. All authors have read and agreed to the published version of the manuscript.

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## Conflict of interest

The authors declare no conflict of interest.

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