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# Mislabeling in Indian Branded Health Foods: Case Study with Immunity Booster Food and Protein Supplement

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***Abstract***

*One of the most recent risks to livelihood security is food "mislabeling". Mislabeling occurs when the label on the packaging does not convey the true character of the product with respect to quality, components, nutritional values and health advantages. Mislabeling includes modifying the original recipe, substituting a component, omitting required warning words, and concealing the presence of certain potentially dangerous ingredients. Purposeful mislabeling is done for financial advantage, whereas inadvertent mislabeling occurs when food manufacturers lack awareness of food safety regulations. Mislabeling can happen with any packaged food product. Unfortunately, health foods are also not out of the grip of mislabeling. "Health food" refers to any food that is touted as being extremely beneficial to one's health. The health food market is one of the fastest expanding markets globally, especially after COVID-19 pandemic. The two most popular goods in this category are protein supplements and immunity booster food supplements. Here we report nutritive assessments of four protein supplements and five immunity booster food supplements which are popular in the Indian market and contain improper labeling. In order to assess the scope of mislabeling in these products, protein supplements were tested for their protein, fat and total carbohydrate content and the immunity booster food supplements were analytically tested for vitamin C and zinc content and antioxidant activity. Notable disparities, as high as 1900%, were found between the printed value and the estimated value of certain nutrients. This clearly shows the prevalence of mislabeling in Indian health food sector and underscores the importance for stringent labeling regulation and implementation.*

**Keywords:** Food safety, health supplements, immunity booster, mislabeling, protein powder, quantitative study

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## INTRODUCTION

Mismatch between the information printed on the food labels and the actual content present inside is termed as mislabeling. Some of the common instances of mislabeling are nutritional content misrepresentation, ingredient substitution, false health claims, use of the word "organic" without certification, use of undeclared additives, false allergy-free claims, etc. [1]. Mislabeling is a great threat to the health of consumers as labels are the only means to know about the content which is present inside a packaged food. With the socio-economic changes and the improvements in food technology, consumption of packaged food has increased manifold over the last couple of decades [2]. It can be anticipated that a larger population will be impacted by mislabeling with the increasing consumption of packaged food. Problem of

 

mislabeling exists worldwide; however, the chances are more in developing countries due to less stringent food laws, loopholes in the existing laws and its implementation, and lack of awareness amongst consumers about food labels. Consequences of mislabeling encircle all the aspects of our society. Apart from severely deteriorating the health of the consumers, studies have also revealed its substantial impact on the environment as well as the financial status of society [3]. Some of the apparent dangers posed by mislabeling are severe allergic reactions upon consumption of food, which did not mention possible presence of any allergen on its package, irreversible organ damage, malnutrition etc. Reacting to the cases of food fraudulent can be quite expensive, for example the annual cost of recalls due to food fraud is estimated to be over EUR 30 billion, according to the global food business [4]. Food fraud also has a negative impact on customers' faith in the food industry and governmental organizations.

Health supplement is a term coined for those food products which are intended to enhance the diet and are different from conventional food [5]. Due to the wide variety of consumers with different preferences, there exists a broad range of health supplements to cater to diverse needs. Some of the popular forms are drinks, tablets, capsules, soft gels, gel caps, powders, bars, gummies, and liquids. Some supplements are developed mainly to enrich the diet with only one or two types of macro/micro-nutrient like protein, vitamins, minerals, amino acid supplements, etc. Out of the varied variety of health supplements the two most popular types are *Protein supplements* and *Immunity Booster Food Supplements*. Protein supplements serve as concentrated sources of protein, aiding tissue repair, muscle building, catalyzing biochemical processes, and providing structural support [6]. These can be incorporated into various foods and beverages, offering versatility in consumption methods. These supplements come in diverse compositions, ranging from pure protein sources to blends with carbohydrates or other additives like creatine and vitamins. Benefits of consuming protein supplements include weight management, muscle growth, post-exercise recovery, and enhanced nutrition. The second most popular health food is Immunity boosters**,** which aim to enhance the body's defense system against infectious as well as immunity related diseases. The immunity boosters are categorized into two main classes; (i) drug based and (ii) food based. This study concentrates on the second variety i.e. immunity booster food supplements, which come in the form of tea, beverages, gummies, spices, powders, juices, etc. Drug-based forms, such as, pills, capsules, tablets, syrups, etc. are not part of this current study. Each component of the immunity booster food supplements has the potential to improve immunity health *via* a variety of pathways, including modification of immunity cell function, antioxidant activity, and gut microbiome support [7]. Popularity of these immunity booster food supplements increased manifolds during the Covid-19 and post-Covid era. The annual market growth of health supplements worldwide was estimated to be US $ 177.50 billion in 2023 and the expected Compound Annual Growth Rate (CAGR) from 2024 to 2030 is 9.1% [8].

The rising popularity of health supplements and the growing demand in the market have prompted the occurrence of various malpractices, including issues, such as mislabeling and adulteration, both in India and abroad. In the recent past, a significant number of mislabeling cases have been registered for health supplements in India. A survey conducted in New Delhi in 2020-2021 reported that out of 1, 07,829 food samples analyzed by FSSAI, 28,347 samples did not meet the standards prescribed by FSSAI [9]. In another investigative study conducted in the USA, 30 dietary supplements were analyzed which claimed to have health and immunity benefiting compounds [10]. Almost 56% (17 samples) were reported to be mislabeled. For example, some of the ingredients enlisted in the label were not detected in the product, whereas some of the additives used were not listed in the label. A critical case was reported in Bengaluru, India where an individual suffered from kidney failure because of prolonged consumption of drinks from a well-known global nutrition company in order to lose weight [11].

In India, protein supplements and immunity booster food supplements are regulated by Food Safety and Standards Authority of India (FSSAI). The FSSAI acts under the sections 50, 51, 52, and 65 cover various aspects of fraudulent activities related to the food sector and associated punitive measures.

 

However, proper implementation of these rules and regulations is lacking due to which the manufacturers with a "money making mindset", are successful in committing offenses at the risk of customer's health [12].

Unfortunately, there are not many studies reported in India on the serious topic of food fraud, especially mislabeling, in health supplements. In a recent market survey (unpublished data) conducted by our research group found that out of 200 Immunity booster food supplements available in various e-commerce sites of India, 25% were violating one or multiple labeling regulations given by FSSAI. During a consumer survey done by our group on the protein supplements users, many users complained that they did not get the desired results even after prolonged consumption of the protein supplements. These preliminary findings prompted us to take up the current project, where nutritional evaluation of some of the vital macro and micronutrients was carried out on randomly chosen commercially available protein supplements and immunity booster food supplements. The estimated values were compared with the values printed on their package labels (if any) or recommended dietary intake. Protein supplements were tested for protein, fat and carbohydrate content, whereas, immunity booster food supplements were tested for Vitamin C, zinc and radical scavenging activity (DPPH assay).

## MATERIALS AND METHODS

### Material Reagents

Potassium iodide (AR grade), Iodine (LR grade), starch, Hydrochloric acid (AR grade), EDTA (Ethylenediaminetetraacetic acid-LR grade), Methanol (AR grade), Acetate buffer, Xylenol orange, DPPH (2,2 Dipheny1-picrylhydrazine),Copper sulphate, Sodium potassium tartrate, sodium hydroxide, hydrochloric acid, sulfuric acid, sodium carbonate, potassium sulfate, boric acid, petroleum ether, methyl red indicator, bromocresol green, Folin-Ciocalteu reagent, Bovine serum albumin, D-Glucose were purchased from either SD Fine, or Sisco Research Laboratory (SRL). All chemicals were used as they were received from the chemical manufacturer without any processing or purification.

### Samples

Four protein supplements and five immunity booster food supplements were chosen (Table 1) as test samples for quantitative estimation. The selection was made based on improper labeling or due to the complaints from the users regarding their ineffectiveness.

**Table 1.** List of samples chosen for quantitative analysis.

| Sample Code | Category of the Product | Type of the Product |
|---|---|---|
| A | Protein supplements | Powder |
| B | Protein supplements | Powder |
| C | Protein supplements | Powder |
| D | Protein supplements | Biscuit |
| E | Immunity booster | Masala powder |
| F | Immunity booster | Gummy |
| G | Immunity booster | Juice |
| H | Immunity booster | Mulethi powder |
| I | Immunity booster | Amla powder |

## METHODS

### Estimation of Protein

Protein estimation was done using Kjeldahl method as described by Saxton et al. (2021) [13]. With little modification. Details of the procedure are described below.

#### *Digestion*

Each sample was run in triplicates. Three crucibles were filled up with sample (0.5 g each), 3 g catalyst mixture and 10 mL of concentrated sulfuric acid. The fourth crucible was kept as blank

 

containing the catalyst mix and sulfuric acid. The tubes were kept for digestion for five ramp cycles. Upon completion of digestion, the samples exhibited a bluish-green hue. The tubes were then removed from the digestion block and transferred to a cooling stand to facilitate cooling and to proceed with the distillation process. Hygroscopic samples were wrapped in butter paper and kept for digestion. In order to maintain uniformity across samples and blanks, the same size of butter paper was kept in all the sample tubes and the blank tube.

***Distillation***

The tubes were allowed to cool, with a consistent flow of water to facilitate cooling. A 40% NaOH solution was introduced as an inlet for distilling the sample. A mixture of 4% boric acid and 4 drops of indicator was used to capture the released nitrogen post-distillation. Distilled water continuously flowed into the system. Upon initiating the system, steam was generated. Tubes were loaded sequentially for the distillation process. Each tube was subjected to a distillation run after loading (Table 2).

***Titration***

Following distillation, the nitrogen trapped in the boric acid was titrated using 0.1 N HCl. HCl was incrementally added to the solution until the color shifted from green to pink, at which point the titer value was recorded. Protein content was measured using the following equation.

$$\% \text{ Nitrogen} = \frac{14 \times Normality\ of\ acid \times Actual\ titer\ value \times 100}{weight\ of\ the\ sample\ (g) \times 1000}$$

$$\% \text{ Protein} = \% \text{ Nitrogen} \times 6.25$$

**Estimation of Fat Content**

Fat content of the protein supplements was carried out using Soxtron, following the principle of Soxhlet extraction [14]. Each sample was run in triplicate. Each sample was weighed (1g) and put inside the thimble for fat estimation. The empty weights of the collection vessels were recorded. The samples were extracted with hexane for 90 minutes. After the process, the collection vessels were taken out of the instrument, dried and weighed.

$$\text{Total Fat } \% = \frac{W_f - W_i}{W_s} \times 100$$

where,

$W_s$ – Weight of sample taken for extraction (in g).

$W_i$ – Initial weight of collecting tube (in g).

$W_f$ – Final weight of collecting tube (in g).

**Estimation of Total Carbohydrate Content [15]**

Total carbohydrates present in the protein supplement samples (A–D) was estimated using Phenol-sulfuric acid method. Each sample was tested in duplicates.

***Standard Preparation***

D-Glucose was used as the working standard. Glucose (0.2 g) was dissolved in 100 ml of distilled water. This solution was diluted with distilled water in 1:9 ratio. This was considered as the working standard.

***Sample Preparation***

Each sample (5 g) was digested with 10 ml of concentrated hydrochloric acid for 3 hours. Upon completion, the sample was neutralized using sodium carbonate slowly until the effervescence settled. After neutralization, the sample was transferred to a 100 ml volumetric flask and the volume was made up to 100 ml using distilled water. This sample was further used for the assay.

 

***Procedure***

Test tubes were cleaned and labeled as the following: 0.4, 0.8, 1.2, 1.6 and 2.0 (for standards) and A (1), A (2), B (1), B (2), C (1), C (2), D (1), D (2) (for samples), as the samples were run in duplicates. With a clean pipette, 0.4 ml, 0.8 ml, 1.2 ml, 1.6 ml and 2.0 ml of the working standard solution was pipetted out in respective test-tubes. The volume in each tube was made up to 2 ml using distilled water. Another tube was prepared with only 2.0 ml of distilled water as blank. In sample test tubes, 2.0 ml of sample solution was pipetted. To each test tube (blank, standards and samples) added 1 ml of sulphuric acid, 0.2 ml of phenol solution, vortexed thoroughly and kept in water bath (40 °C) or incubation for 20 minutes. The tubes were cooled down to room temperature and the absorbance was recorded at 490 nm using a colorimeter.

**Estimation of Vitamin C in Immunity Booster Food Supplements [16]**

***Sample Preparation***

- *Sample-E:* 1 g of sample was taken in a conical flask; 20 ml of water was added to it and stirred at room temperature until dissolved.
- *Sample-F:* 0.5 g of ground sample was weighed and mixed with 20 mL of water, stirred at room temperature until dissolved.
- *Sample-G:* 5 ml of sample was diluted with 150 ml of water to prepare the test solution.
- *Sample H:* 0.1g of sample was added to 100 ml of water and shaken at room temperature until dissolved.
- *Sample-I:* 0.1g of sample was mixed with 100 ml of water and stirred at room temperature until dissolved.

***Titration***

An aliquot (5 mL) of the sample solution was pipetted into a 250 ml Erlenmeyer flask and 0.5ml of starch indicator was added to it. The sample was titrated with 0.005 mol/L iodine solution. The end point of the titration was identified as the solution turned dark blue. The titration was repeated until concordant results were obtained. The number of moles of iodine that reacted with vitamin C present in the sample extract was determined from the titer value. The number of moles of vitamin C present in the titration flask was calculated considering 1:1 stoichiometric reaction between Vitamin C and iodine.

Subsequently the number of moles were converted to gram and concentration in the original sample was reported in g/10 g and g/serving size. To validate the estimation protocol, before analyzing the test samples, Vitamin C content of FDA certified vitamin C tablet was measured and compared with its printed values.

**Estimation of Zinc [17]**

***Sample Preparation***

Sample (*Sample-E:* 1 g, *Sample-F:* 0.5 g, *Sample-G:* 1 ml, *Sample-H:* 0.1, *Sample-I:* 0.1) was dissolved in 10 ml of HCl and 5 ml of buffer. For samples E, F, G, this solution was directly titrated with EDTA after adding 2-3 drops of xylenol orange indicator. However, for samples H and I, the solution was centrifuged for 15 minutes at 1500 rpm and the supernatant was used for titration. 2–3 drops of xylenol orange was added as indicator.

***Titration***

15 ml of sample solution was taken into a conical flask. It was titrated against 0.015 M EDTA. The end point was identified as the solution turned from red to yellow.

***Calculation***

Number of moles of EDTA was calculated from the titer value. The number of moles of zinc was found considering chelation between zinc and EDTA in 1:1 stoichiometry. The end point was determined by color change from orange to yellow.

 

**Estimation of Antioxidant Activity in Immunity Booster Food Supplements by DPPH Radical Scavenging Assay [18]**

***DPPH Solution Preparation***

DPPH (0.03 g) was dissolved in 80 ml of methanol and mixed until it dissolved. The freshly prepared DPPH solution was used for testing.

***Sample Preparation***

Sample (*Sample-E:* 1 g, *Sample-F:* 1 g, *Sample-G:* 1 ml, *Sample-H:* 1 g, *Sample-I:* 1g) was added to 10 ml of water and stirred until dissolved. Thus, a prepared solution of samples E, F, G could be directly used for testing. However, for samples H and I, the mixture was centrifuged for 15 minutes at 1500 rpm, and the supernatant was taken for analysis.

***Absorbance Measurement***

0.1 ml of sample solution was pipetted into a test tube containing1 ml of DPPH solution, vortexed and kept under dark for 30 minutes. The absorbance was recorded at 517 nm ($A_C$).

Similarly, 0.1 ml of distilled water was pipetted into a test tube containing 1 ml of DPPH solution, vortexed and kept under dark for 30 minutes. The absorbance was recorded at 517 nm ($A_S$)

$$\% \text{ of Antioxidant Activity} = \frac{A_C - A_S}{A_C} \times 100$$

where,
$A_C$ = Absorbance of the control (DPPH).
$A_S$ = Absorbance of the sample.

## RESULTS AND DISCUSSION

### Protein Content

Quantification of protein in the four selected protein samples were carried out using the protocol described in Materials and Methods sections. The results obtained have been compiled in Table 2. All samples were found to contain protein in detectable amounts.

For all four protein samples, significant differences were observed between the printed and estimated values. Protein content in sample A was estimated to be 27.12 g which is approximately 46% less than the printed value of 50.0 g.

Similarly, Sample B, C and D showed 25.0%, 38.2% and 15.4% negative deviation in the protein content from the printed value. These findings clearly show violation of the Food Safety Acts and mislabeling.

**Table 2.** Protein Content estimation of tested protein supplements.

| Sample Codes | Protein Content (g/100 g), as Printed on Package ($P_p$) | Protein Content (g/100g), as Estimated ($P_{a*}$) | Difference from Printed Value $\{(P_p - P_a)/P_p\} \times 100\%$ |
|---|---|---|---|
| A | 50.00 | 27.12 ± 0.97 | 45.8% |
| B | 40.00 | 30.00 ± 1.27 | 25.0% |
| C | 34.00 | 21.00 ± 1.06 | 38.2% |
| D | 30.00 | 25.37 ± 0.94 | 15.4% |

*Note: *Values are mean ± standard deviation. N = 3.*

### Fat Content

Fat content in the four protein supplement samples was estimated using Soxhlet extraction method. The results are depicted in Table 3.

 

Surprisingly, the fat content in each sample was found to be much higher than the printed value. For example, fat content in sample A was estimated to be 3.00 g/100 g, which is 265% higher than the printed value of only 0.82 g/100 g. Sample B showed maximum deviation from the printed value, i.e. 1900%. Sample C and D also showed noticeable differences of 36% and 40%. These results point out clear cases of mislabeling and pose a serious threat to the health of the consumers due to over consumption of fat.

**Table 3.** Fat content estimation of tested protein supplements.

| Sample Code | Fat Content as Printed on Package, $F_{p*}$ (g/100 g) | Fat Content as Estimated, $F_{a*}$ (g/100g) | Difference from Printed Value $(F_a–F_p)/F_p\}\times100\%$ |
|---|---|---|---|
| A | 0.82 | 3.00 ± 0.71 | 265.8% |
| B | 0.50 | 10.00 ± 3.18 | 1900.0% |
| C | 14.00 | 19.00 ± 1.41 | 35.7% |
| D | 3.00 | 4.20 ± 2.55 | 40.0% |

*Note: *Values are mean ± standard deviation, n = 3.*

## Total Carbohydrate Content

The total carbohydrate content in the protein supplement samples were carried out using Phenol-Sulphuric acid method. The results are depicted in Table 4. The marked difference between the printed and estimated value was evident in the case of total carbohydrate, too. All samples showed much higher carbohydrate content than those printed on the package. Sample A showed the highest discrepancy with 328% deviation from the printed value. Sample B, C and D were also not left behind and showed 88%, 32% and 26% difference from the printed value. Often protein supplements are spiked with a significant number of flavoring agents and sweeteners to enhance the flavor and acceptability of the supplement, which may result in the observed high carbohydrate content in the supplements. These results again reveal a clear case of mislabeling and the possible threats posed to the consumers by over consumption of carbohydrates. Protein supplements are mostly used for therapeutic use or for weight loss, which will not be possible with such high carbohydrate content.

**Table 4.** Total carbohydrate content of tested protein supplements.

| Sample Code | Total Carbohydrate Content as Printed on Package, $C_p$(g/100 g) | Total Carbohydrate Content as Estimated, $C_a$* (g/100 g) | Difference from Printed Value $\{(C_a – C_p)/C_p\}\times100\%$ |
|---|---|---|---|
| A | 17.0 | 72.8 ±0.03 | 328.0% |
| B | 44.9 | 84.4 ±0.09 | 88.0% |
| C | 53.3 | 70.5 ±0.06 | 32.3% |
| D | 48.0 | 60.6 ±0.01 | 26.2% |

*Note: *Values are mean ± standard deviation, n = 2.*

## Vitamin C Content

In the current study, vitamin C content of the five immunity booster food supplements was quantified by the titration-based method. The method was validated using vitamin C tablets manufactured by Abbott chemicals (APHL). The results obtained from the titrimetric estimation of vitamin C content have been compiled in Table 5. All the samples were found to contain vitamin C in detectable amounts. The values per serving size were found to range from 2.4 mg to 91.6 mg.

Literature says, vitamin C supplements should provide at least 70 to 150 mg of vitamin C per day [19]. Which is clearly not maintained in samples E (6.4 mg), F (2.4 mg) and G (67 mg)? Samples E and G did not even mention the vitamin C content on the package. Sample F claims to contain 90 mg of vitamin C per serving size, however, the estimated value is only 2.4 mg per serving size, which shows clear mislabeling.

 

According to our analysis, only sample-H (91.6 mg/serving) and I (80.7 mg/serving) contain vitamin C in the recommended range of 70–150 mg. However, package of sample I claims to contain only 2.07 mg/serving size. The possible reason behind this mismatch may be an error by the manufacturer while creating the label, because it is very unlikely that any manufacturer will claim to have such an insignificant amount of vitamin C present in their product.

Therefore, overall findings suggest that various food supplements, available in the market and claiming to be immunity boosters, do not contain the recommended range of vitamin C. Three out of the five tested samples were lower than recommended value. In three out of five tested samples, presence of vitamin C was not mentioned at all. The other two products, which mentioned vitamin C content, the printed value did not match with the estimated values. All these results are clear evidence of inaccuracy of the nutritional labels and mislabeling.

**Table 5.** Vitamin C content of tested immunity booster food supplements.

| Sample Code | Serving size (Printed on Package) | Category | Vitamin C Content | | |
|---|---|---|---|---|---|
| | | | ***Printed on Package*** | ***Estimated by Experiment *(mg/g)*** | ***Estimated by Experiment (mg/Serving Size)*** |
| Vitamin C tablet (Reference sample) | 1.08 g | Solid | 500 mg/serving | 491.04 ± 0.40 | 491.0 |
| E | 10.00 g | Solid (powder) | Not mentioned | 0.60 ± 0.10 | 6.4 |
| F | 1 gummy | Solid (jelly) | 90 mg/serving | 2.20 ± 0.10 | 2.4 |
| G | 30.00 ml | Liquid | Not mentioned | 0.60 ± 0.10 mg/ml | 67.0 |
| H | 5.00 g | Solid (powder) | Not mentioned | 18.30 ± 0.20 | 91.6 |
| I | 5.00 g | Solid (powder) | 2.07 mg/serving | 16.10 ± 0.20 | 80.7 |

*Note: *Values are mean ± standard deviation, n = 3.*

## Zinc Content

In the current study, zinc content of the immunity booster food supplements was quantified by the Zn-EDTA titration-based method. Estimation of zinc content in the five chosen samples was carried out as per the protocol described in Materials and Methods section. The results obtained from the titrimetric estimation of zinc content are presented in Table 6.

All the samples were found to contain zinc in detectable amounts. The values range from 5.6 mg (Sample F) to 50 mg (Sample I) per serving size. Zinc content of all five tested samples (Sample-E, Sample-F, Sample-G, Sample-H, Sample-I) was not mentioned on the package. As per ICMR recommendation, zinc supplements should provide zinc between 12 mg to 17 mg per day [20]. Our quantitative estimation results found that per serving of sample E, F, G, H, I contain 20.2 mg, 5.6 mg, 36.0 mg, 30.0 mg and 50.0 mg of zinc. The estimated zinc content varies notably among the different samples. All samples except sample E contain Zn either significantly higher or lower than the recommended value. Sample G, H, and I exceed the upper limit of the recommended daily zinc intake according to ICMR guidelines, while sample F falls below the recommended range. Thus, samples G, H and I may cause over consumption of zinc leading to gastrointestinal issues like nausea, vomiting and diarrhea.

## Anti-Oxidant Activity by DPPH Radical Scavenging Activity

In the current study, radical scavenging activity of the immunity booster food supplements was measured by DPPH method described in materials and Methods section. Table 7 presents comparison

 

of the radical scavenging activities of the samples E, F, G, H, and I with the reference sample "Vitamin C tablet".

**Table 6.** Zinc content of tested immunity booster food supplements.

| Sample Code | Serving Size (Printed on Package) | Category | Zinc Content | | |
|---|---|---|---|---|---|
| | | | ***Printed on Package*** | ***Estimated by Experiment* (mg/g)*** | ***Estimated by Experiment (mg /Serving Size)*** |
| E | 10.0 g | Solid (powder) | Not mentioned | 2.0 ± 0.2 | 20.2 |
| F | 1 gummy | Solid (jelly) | Not mentioned | 1.4 ± 0.2 | 5.6 |
| G | 30.0 ml | Liquid | Not mentioned | 1.2 ± 0.2 | 36.0 |
| H | 5.0 g | Solid (powder) | Not mentioned | 6.0 ± 0.2 | 30.0 |
| I | 5.0 g | Solid (powder) | Not mentioned | 10.0 ± 0.2 | 50.0 |

*Note: *Values are mean ± standard deviation, n = 3.*

All samples showed radical scavenging activity % much lower than the reference sample Vitamin C tablet. Amongst the five tested samples, Sample E (46.09%) and G (41.73%) demonstrate relatively high radical scavenging activity, but that is still lower than that of the Vitamin C tablet (64.34%). Sample I (17.39 %), sample F (13.04%) and sample H (10.43%) show insignificant radical scavenging activity compared to the Vitamin C tablet.

Overall, none of the tested immunity booster food supplements matched the high antioxidant potency of the Vitamin C tablet. These findings suggest that the tested immunity boosters are far away from the Vitamin C tablets with respect to being an effective source of antioxidants.

**Table 7.** Radical scavenging activity of tested immunity booster food supplements.

| Sample Code | Category | Radical Scavenging Activity (%)* |
|---|---|---|
| Vitamin C tablet (Reference Sample) | Solid (powder) | 64.34% ± 0.02 |
| E | Solid (powder) | 46.09% ± 0.01 |
| F | Solid (jelly) | 13.04% ± 0.02 |
| G | Liquid | 41.73% ± 0.02 |
| H | Solid (powder) | 10.43% ± 0.02 |
| I | Solid (powder) | 17.39% ± 0.02 |

*Note: * Values are mean ±standard deviation, n = 3.*

## SUMMARY AND CONCLUSIONS

Comparison of the estimated values of protein, fat and total carbohydrates content in the four selected protein supplements with the values printed on their packages found significant disparity across all samples. All samples were found to have lower protein content and higher fat and carbohydrate content than the values printed on their respective packages. These findings clearly indicate mislabeling and non-compliance with regulatory standards, raise concerns regarding the uncounted intake of carbohydrates and fats by the consumers (particularly for individuals employing protein supplements for therapeutic or weight management purposes), and highlights the necessity for enhanced labeling precision for the protein supplements available in e-commerce sites of India.

Similar trends could be observed in case of immunity booster food supplements. Chemical analyses of the five chosen samples, with "immunity booster" tag on packaging, revealed a wide variability in the vitamin C and zinc content among different formulations and serving sizes. The investigation revealed notable disparities between the printed and actual vitamin C content in the sampled products, indicating inconsistent labeling practices within the immunity booster supplement industry.

 

Similarly, a wide range in zinc content was observed among the tested samples, highlighting the need for standardized formulation and labeling procedures to ensure product safety and efficacy. The absence of nutritional labeling on most of such immunity booster food supplements was a concerning finding, depriving consumers of essential information for informed decision-making.

## CONTRIBUTIONS

Jhinuk Gupta developed the research concept, designed the experiments and compiled the manuscript for submission. Shreya P Sarathy executed the experiments related to protein supplements, processed the related experimental data and performed calculations. Tharani Lakshmi Tharuni executed the experiments related to Immunity booster food supplements, processed the related experimental data and performed calculations. Amrita Shaw supervised and monitored the experiments and helped in editing the manuscript.

## Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this article.

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