

Student Knowledge, Consumption Patterns and Health Effect of Using the ‘Fortified Food’: A Cross-Sectional Study Among Rural and Urban Areas College Students

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Abstract: **Background:** Food fortification is a key nutritional intervention aimed at preventing and controlling micronutrient deficiencies globally. By adding essential nutrients, such as vitamins and minerals, to improve their nutritional value. These nutrients may be lacking in natural foods due to various factors like soil depletion, processing and cooking. Fortification helps prevent nutrient deficiencies, promotes overall health, and supports specific bodily functions. Fortified foods play a crucial role in maintaining public health, particularly in regions where access to nutrient-dense foods is limited. Fortified foods are enriched with various nutrients, including – Iron, Calcium, Zinc, Folic acid, Potassium, Vitamin-D, Vitamin-A, Vitamin-B12, Omega-3-fatty acids etc. These nutrients are added to various food products to enhance their nutritional value and help to prevent deficiencies of different micronutrients like iron (deficiency of which results anaemia), vitamin D (deficiency of which results rickets and osteomalacia), vitamin A (deficiency of which results xerophthalmia), calcium & vitamin D (deficiency of which results osteoporosis) etc. **Objective:** The study aimed to determine the knowledge, consumption and effect on health towards the usage of fortified food among rural and urban areas college going students. **Methods:** This was a cross-sectional study conducted in the college students having the age group between 19 – 24 years. The study was carried out by random sampling among 100 students. This survey study was carried out through questionnaires method and a face-to-face interview among those students.

Keywords: Awareness, Enrichment, Fortification, Knowledge, Malnutrition, Micronutrients.

1. Introduction

In today's fast paced world, where access to a balanced diet is not always readily available, food fortification has emerged as a cost-effective strategy to combat nutrition deficiencies. For example – Breakfast cereal may be fortified with iron, the glass of milk likely has vitamin D added, and evening bowl of pasta could be fortified with folic acid [1].

The Food Safety and Standard Authority of India (FSSAI) up define fortification as “deliberately increasing the content of essential micronutrients in a food so as to improve the nutritional quality of food and to provide public health benefit

with minimal risk to health”. In India, the FSSAI implemented the Food Safety and Standards (Fortification of Foods) Regulations, 2016 to mandate fortification of key staples—wheat flour and rice (with iron, vitamin B12, folic acid), milk and edible oil (with vitamins A and D), and double fortified salt (with iodine and iron). It help consumers identify such products, the '+F' logo was introduced. These regulations were officially notified in the Gazette of India on 9th August 2018 [2].

Micronutrients, though required in small amounts, are vital for brain and immune function. Deficiencies can cause stunting, wasting, anaemia, and birth defects. According to WHO, over 2 billion people suffer from micronutrient deficiencies, with iron, iodine, folate, vitamin A, and zinc being the most common [3]. Especially in women and children, micronutrient deficiencies arise from poor diets and health issues. Fortifying staple foods is a proven strategy to reduce these deficiencies [4]. Fortification of wheat flour with folic acid may reduce the risk of neural tube defects and may increase erythrocyte and serum/plasma folate concentrations. Fortification of wheat flour with iron may reduce anaemia in the general population. Staple foods may be fortified with vitamin D for the prevention and reduction of nutritional rickets.

Fortification of foods with zinc may improve the serum zinc status. There are no reported side effects associated with single or micronutrients fortification [5].

Food fortification can significantly improve nutrition and health. Over 70% of the Indian population consumes less than half the daily recommended dietary allowance of micronutrients a day. These deficiencies affect all population groups in India – urban, rural, rich, poor, old, and young [6]. Utilizing fortification or enrichment, restoration, standardization, and supplementation processes, more nutrients are added to food [7].

2. Review of Literature

1. Saskia J. M. Osendrap et al. (2018), told that biofortification is the process of adding essential nutrients

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to food products to enhance their nutritional value. Here biofortification and food fortification both are parallel term to establish strategies for addressing micronutrient deficiencies in specific at-risk population. It not only mentioned that the biological efficacy of fortified food but also it helps to monitor and corrective measure to ensure high applicability [8].

2. Dwyer JT, Wiemer KL et al. (2015) told that, the process of fortification involves adding nutrients or bioactive components to food to address nutrient intake shortfalls and improve public health. Fortification has been effective at reducing the risk of nutrient deficiency diseases such as beriberi, goitre, pellagra, and rickets. While historically focused on eliminating deficiency diseases, modern fortification targets low dietary intakes [9].
3. Vishwakarma S, Genu Dalbhagat C et al. (2022) told that, micronutrient malnutrition (MNM), often termed "hidden hunger," poses a significant health challenge, especially affecting children and women worldwide. Traditional methods like dietary diversification, supplementation, and fortification have been utilized, but a novel approach, food-to-food fortification (FtFF), is gaining attention. FtFF involves enriching commonly consumed foods with micronutrient-dense ingredients, such as basil, moringa, and fenugreek. By leveraging natural fortificants, FtFF offers a promising strategy to address micronutrient deficiencies and promote better health outcomes [10].
4. Lutter CK, Dewey KG (2003) told that, fortified processed complementary foods (FPCF) for infants and children, emphasizing nutrient composition and daily ration sizes. It includes specific fortification levels for essential nutrients like iron, zinc, vitamins, and minerals, aiming to meet dietary requirements effectively. Precooking is recommended to prevent micronutrient loss, but further research is needed for optimal formulations [11].
5. Olson R, Gavin-Smith B et al. (2021) stated that food fortification addresses widespread micronutrient deficiencies in low- and middle-income countries, enhancing physical and cognitive health. Despite global debates on its efficacy and safety, fortification—via large-scale, biofortification, and home methods—proves cost-effective, delivering health, economic, and social benefits. Successful programs emphasize partnerships involving public, private sectors for advocacy, management, and regulatory oversight [12].

3. Materials & Methods

It describes the various methods and materials used in investigation research aim. Various questions were asked through questionnaire in order to get general information and information related to survey from college students between the age group of 19-24. Required data of the samples in the study were gathered with the help of 3 categories of questions; general information, socio-democratic factors, and survey related questions. A structured and pre-tested questionnaire was used to gather data related to the objectives of the study.

A. Method of the Study

1) Study Population

- 1) The study was carried out among female and male, college-university students having the age group between 19-24 years.

2) Study Variables

a) Dependent Variables

- i. Different types of fortified food consumption.
- ii. Nutrients come from fortified food - Folic acid (vitamin B9), Iron, Vitamin D, Calcium, Vitamin B12, Vitamin C, Vitamin A, Vitamin E, Omega-3 fatty acids, Fiber, Zinc etc.

b) Independent Variables

- i. Socio-demographic factors like Age, Sex, Activity type, Type of family, Total number of family members.
- ii. Socio-economic status.
- iii. Knowledge about 'Fortified Food', Food habits, Likes and Dislikes.

3) Study Techniques

- Questionnaire method of survey.
- Face to Face interview with the study subject.
- Height, weight, age, food habits etc. information will be collected by the help of questionnaire furnished.

B. Graphical Presentation

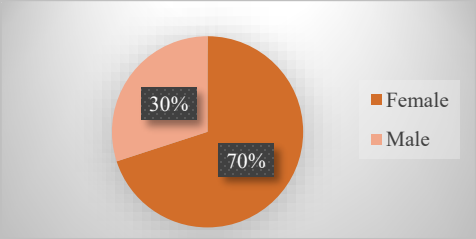
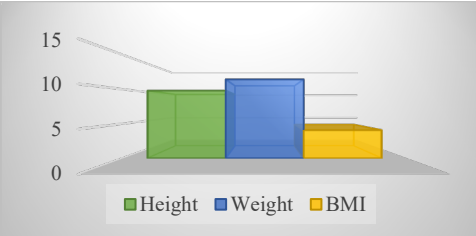
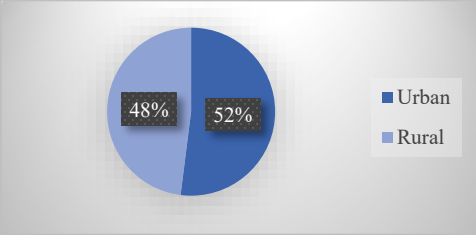
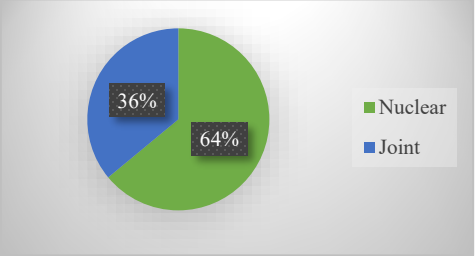
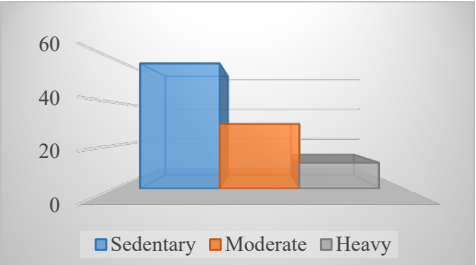
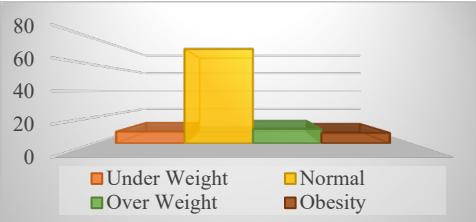
Graphical presentations one of the important parts of my survey work. With the help of graphical charts many data of this survey will be illustrated. Those graphs will help us to demonstrate the conceptual ideas about this survey.

- 1) *Pie Chart*: A pie chart is a circular diagram that represents data as slices of a circle, where each slice corresponds to a category's proportion of the whole. It is useful for showing percentage distribution or the relative share of different components.
- 2) *Column Chart*: A column chart is similar to a bar chart but uses vertical bars instead of horizontal ones. It is particularly useful for showing changes over time, frequency distribution, or comparisons among discrete items.

C. Statistical Analysis of Data

- 1) *Determination of Mean, Median & Standard Deviation*: Mean, Median and Standard deviation were determined by using Microsoft Excel version 2021 on the laptop.
- 2) *Determination of Chi-Square*: One use of (X^2) is to test whether two attributes are independent or associated. They are independent if the distribution of the one attribute in no way depends on the distribution of the other attribute. On the other hand, if they are not independent, there is an association between them. In general, a table having 'r' rows and 'c' columns is known as 'r × c contingency table'.

Table 1
Basic information table with graphical representation of general and socio-demographic factors of the collected samples

S. No.	Variables	No. of Variables (n)	Mean	Median	Standard Deviation	Graphical Presentation
1.	Gender	Female n= 70 Male n= 30	50	50	20	 <p>Fig. 1. Gender</p>
2.	Height	n= 100	159.81	160	9.79	 <p>Fig. 2. Standard Deviation of Height, Weight & BMI</p>
3.	Weight	n= 100	58.68	58	11.42	
4.	BMI	n= 100	22.81	21.9	4.08	
5.	Location	Urban n= 52 Rural n= 48	50	50	2	 <p>Fig. 3. Locations</p>
6.	Family Type	Nuclear n= 64 Joint n= 36	50	50	14	 <p>Fig. 4. Family Type</p>
7.	Activity Type	Sedentary n= 58 Moderate n= 30 Heavy n= 12	33.33	30	18.93	 <p>Fig. 5. Activity Type</p>
8.	Nutritional Status as per BMI	Under Weight n= 9 Normal n= 72 Over Weight n= 11 Obesity n= 8	25	8	27.17	 <p>Fig. 6. Nutritional Status as Per BMI</p>

To apply this test, we formulate the null hypothesis as “the two attributes are independent”. When the calculated value of X^2 is less than the table value of X^2 at a certain level of significance for a given degree of freedom, we accept the null hypothesis and conclude that the two attributes are independent. On the other hand, if the calculated value of chi-square is greater than the tabulated value of X^2 , the null hypothesis is rejected and then it may be concluded the two attributes are associated.

The Chi-square of the sample data was determined by using following formula,

$$\begin{aligned} \text{Chi-square} &= (O_1 - E_1)^2/E_1 + (O_2 - E_2)^2/E_2 + (O_3 - E_3)^2/E_3 + \dots \\ &+ (O_n - E_n)^2/E_n \\ &= \sum (O - E)^2/E \end{aligned}$$

[Where, O stands for observed frequency and E stand for expected frequency]

D. Statistical Inference

- 1) **Null Hypothesis (H_0):** The null hypothesis is a test that always predicts no effect or no relationship between variables. If the observed value is less than that of tabulated value, the null hypothesis has been accepted at 5% level of significance.
- 2) **Alternative Hypothesis (H_A):** The alternative hypothesis is a test that predicts an effect or relationship may be present between variables. If the observed value is greater than that of tabulated value, then the null hypothesis is rejected and the alternative hypothesis has been accepted at 5% level of significance.

4. Results & Discussion

A. Section- I

See Table 1.

B. Section- II

The results and discussions of the chi-square test for Homogeneity are given below.

1) Chi-Square Test to Show the Relationship Between the Knowledge About Fortified Foods Among Urban and Rural Areas College Going Students: (Table 2)

$$\begin{aligned} \text{Chi-Square}(X^2) &= (O_1 - E_1)^2/E_1 + (O_2 - E_2)^2/E_2 + (O_3 - E_3)^2/E_3 \\ &+ (O_4 - E_4)^2/E_4 \\ &= (41-39)^2/39 + (34-36)^2/36 + (11-13)^2/13 + (14-12)^2/12 \\ &= 0.10 + 0.11 + 0.31 + 0.33 \\ &= 0.85 \end{aligned}$$

The calculated Chi-Square result is 0.85

$$\begin{aligned} \text{Degree of Freedom (D.F)} &= (2-1) \times (2-1) \\ &= 1 \end{aligned}$$

Since the observed Chi-square (X^2) value (0.85) has been found less than that of the tabulated value (3.84) at 5% level of significance for 1 degree of freedom. So, we can accept the Null Hypothesis (H_0), which means there is no relation between the knowledge about fortified foods among urban and rural areas college going students. So, we may conclude, that the knowledge of Fortified foods does not depend on urban and rural areas students.

- *Graphical Representation of the Sample has been Presented Below*

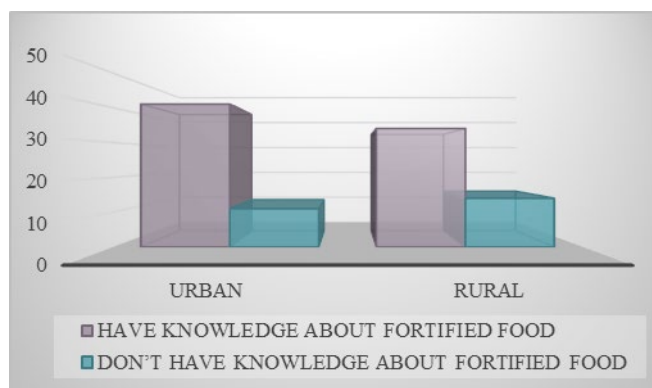


Fig. 7. The knowledge about fortified foods among urban and rural areas college going students

2) Chi-Square Test to Show the Relationship Between Daily and Rarely Based Consumption of Fortified Foods Among Urban and Rural Areas College Going Students: (Table.3)

Since the observed Chi-square(x^2) value (5.69) has been found greater than that of the tabulated value (3.84) at 5% level of significance for 1 degree of freedom. So, we can reject the Null Hypothesis (H_0), and accept the Alternative Hypothesis (H_a), which means there is a relation present between the two variables. Different areas and fortified foods consumption are two factors that determine the Chi-square value. So, we may conclude with 95% confidence, that consumption of fortified foods depends on different areas. We know that the consumption of fortified foods depends on various factors like – food habit, food type, health benefits, like, dislike and many others. Our test value also concludes that ‘consumption of Fortified foods depends on different areas (like urban and rural). So, it can be said, this Chi-square result supports my survey work.

Table 3

Localities'	Consumption		Total	Chi-Square (X^2) Value
	Daily	Rarely		
Urban	33	19	52	5.69
Rural	19	29	48	
Total	52	48	100	

Table 2

Localities'	Knowledge		Total	Chi-Square (X^2) Value
	Have Knowledge About Fortified Food	Don't Have Knowledge About Fortified Food		
Urban	41	11	52	0.85
Rural	34	14	48	
Total	75	25	100	

- Graphical Representation of the Sample has been Presented Below.

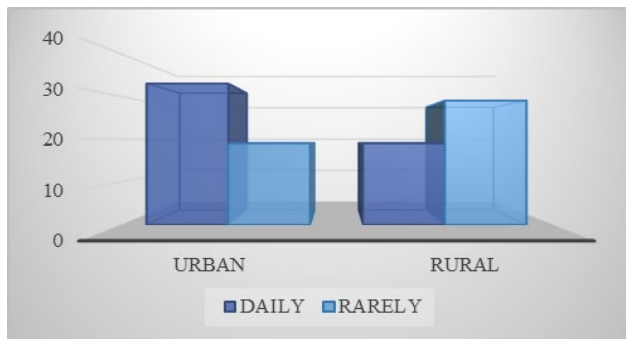


Fig. 8. Daily and rarely based consumption of fortified foods among urban and rural areas college going students

3) Chi-Square Test to Show the Relationship Between the Choice of Fortified Foods Among Urban and Rural Areas College Going Students: (Table 4)

Localities [*]	Choice		Total	Chi-Square (χ^2) Value
	Like	Dislike		
Urban	42	10	52	0.49
Rural	36	12	48	
Total	78	22	100	

Since the observed Chi-square (χ^2) value (0.49) has been found less than that of the tabulated value (3.84) at 5% level of significance for 1 degree of freedom. So, we can accept the Null Hypothesis (H_0), which means there is no relation between the choice of fortified foods among urban and rural areas college going students. So, we may conclude, that the Choice of Fortified foods does not depend on urban and rural areas students.

- Graphical Representation of the Sample has been Presented Below

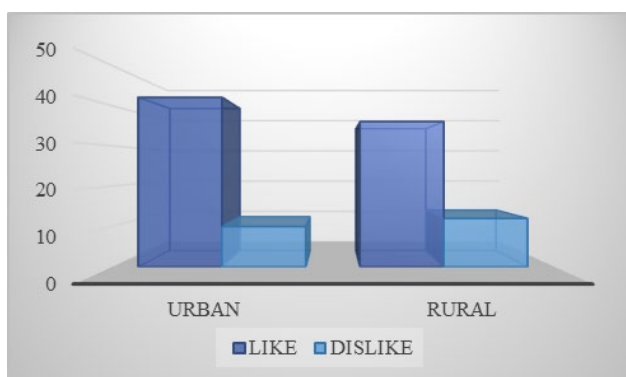


Fig. 9. The choice of fortified foods among urban and rural areas college going students

5. Conclusion

Based on the survey findings and subsequent analysis, it can be concluded that the level of knowledge and food choices regarding fortified foods items are similar in both rural and urban areas but tendency of taking fortified food is not same in rural and urban area. In my study I have found that

urban people take much quantities of micronutrients compare to rural people. These may be due to better economic position of urban people compared to rural people and much availability of fortified food in urban area compared to rural area. Knowledge about fortified food may not be a cause in this case, because I have found that knowledge about fortified food between rural and urban people is statistically same at 5% level of significance.

6. Recommendations

- 1) Much time should be provided to find better result on this study.
- 2) The study should be carried out in broader area to find better result.
- 3) Study should be carried out with at least 300 numbers of samples to get a better idea.
- 4) Awareness program, seminar etc should be carried out through out West-Bengal and India to inspire people for taking fortified foods.

7. Limitations

- 1) In my survey, I have studied with 100 samples. This number is not sufficient to obtain a better result.
- 2) The study has been carried out in limited areas of West-Bengal.
- 3) Answers were collected through questionnaire concerned persons may be confused to reply accurately. In such cases, erroneous result may come.

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