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Development and Qualitative Analysis of Therapeutic Gummies for Anemics

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Abstract

Gummy vitamin is one of the trending sectors of vitamin supplements in this modern era. It has been variedly marketed with health claims and widely accepted and consumed by both children and adults. Anemia is one of the main concerns for females of the reproductive age group, so it is important to administer supplements to enhance their quality of life. Presently, society is eager to opt for fancy ways of consuming vitamin supplements instead of following traditional methods like tablets, capsules, or dietary sources. The consumer preference is shifting more towards chewy, palatable, sweet gummies to recover their vitamin deficiency. To prove this, a consumer preference survey study was conducted on 66 participants between the age group of 13-45, and their responses collected were analyzed. With the concept of iron-enriched gummies, the enriched gummies were formulated focusing on the major nutrient requirements for the anemic population (iron and vitamin C) in three gummy variations (V1, V2, and V3) with ingredients beetroot, lemon, agar-agar, jaggery, rosemary, corn starch. A nine-point hedonic scale was used to conduct a sensory evaluation to compare the acceptability of developed gummies against the standard. It was observed that the developed variation three (GVV3) was best acceptable compared to the standard in terms of appearance, aroma, flavor/taste, texture, color, and overall acceptability. The best variation was subjected to nutrient analysis (iron, vitamin C, and total carbohydrate). Packaging and labeling were done and the product cost was also calculated.

Keywords: gummies, reproductive age group, iron-enriched, anemia, micronutrients

1. Introduction

Iron deficiency anemia is a prevalent health issue in clinical settings worldwide. Iron deficiency remains the leading cause of anemia globally, affecting young children and women of reproductive age groups and developing countries. Iron deficiency is a decline in iron reserves that can occur before or during anemia. It is a severe illness characterized by low iron levels and microcytic hypochromic red blood cells. Over 2 billion people worldwide suffer from anemia, with iron deficiency being the leading cause. An analysis of disease burden confirmed these reports from 187 countries between 1990 and 2010, as well as a survey on the burden of anemia in vulnerable populations like preschool children and young women (1). The National Family Health Survey (NFHS) has been conducted in three rounds (1991-92, 1998-99, and 2005-06) and is a nationwide survey that creates a massive databank on numerous parameters, including iron deficiency anemia among children, women, and men, utilizing the hemacue method. The most recent round (2005-06) showed an extremely high frequency of 65 69.5% among youngsters aged 6-59 months and 55.3% among ever married women. Anemia affected 63.2% of breastfeeding mothers and 58.7% of

pregnant women. Based on studies of ten developing nations, the median value of yearly physical productivity losses owing to iron deficiency is roughly $2.32 per capita or 0.57% of GDP. The median total loss (physical and cognitive) is $16.78 per capita, accounting for 4.05% of GDP. IDA has significant economic repercussions. Despite national and international efforts, the prevalence of anemia in India remains high and has been increasing over time. (2) WHO estimates that 42% of children less than 5 years of age and 40% of pregnant women worldwide are anemic. The development and qualitative study of iron-enriched gummies constitutes a significant step in addressing the global iron deficiency problem, particularly among vulnerable populations such as children and pregnant women. This study, which involved thorough formulation, testing, and evaluation, shed light on the possibility of gummy supplements as a viable method for increasing iron intake. The study's findings have far-reaching implications for public health measures aimed at addressing iron deficiency and its related health risks. Iron-enriched gummies have the potential to reduce nutritional gaps and improve population health outcomes by providing a practical, pleasurable, and accessible supplementation option. Furthermore, the findings of this study can be used to guide future efforts to develop fortified food products, which will employ comparable approaches to address a variety of micronutrient shortages.

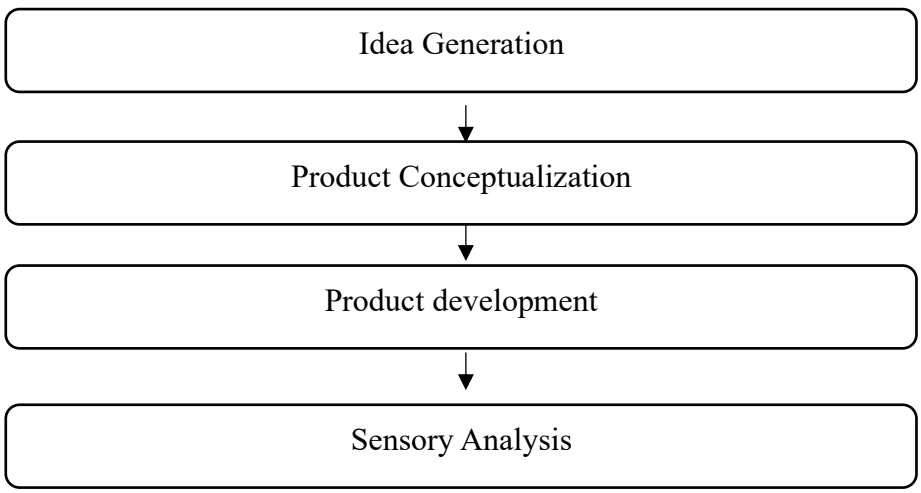
2. Methodology

2.1 Consumer preference survey:

The participants considered for this study were of reproductive age between 13 to 45 years. The samples were collected from diverse locations in India (south, east, west, and north). A well-structured questionnaire was self-designed and divided into two sections: Demographic information includes age, gender, and occupation. The survey was done using a questionnaire created in Google Forms to lessen respondents' non-responsiveness and gather more accurate results.

2.2 Conceptualization:

The study's primary goal was to create iron-enriched gummies by using components that would aid in relieving iron-related symptoms in the reproductive age group. According to the consumer preference survey, the targeted age group suffers from vitamin deficiency, and most of the population opts to use multivitamins to recover. Information on the practical aspects of ingesting gummies was also acquired. Based on the assessment and information acquired, the notion of converting existing gummies into a new upgraded product was developed as a long-term strategic idea to reduce the levels of symptoms. Product development underwent the following steps:



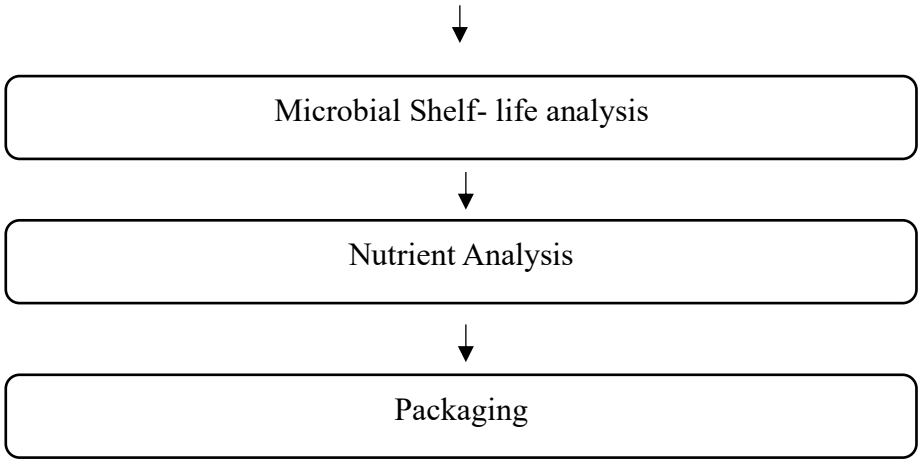


Fig 2.2.1: Stages of food product development (3)

2.3 Research design:

Phase 1 consisted of the following:

- A consumer preference study using a questionnaire among the target population.
- Standardization of gummies and addition of iron-enriched ingredients to develop variations in different formulations (V1, V2, and V3).
- Sensory evaluation of the developed variations to determine the most acceptable product.

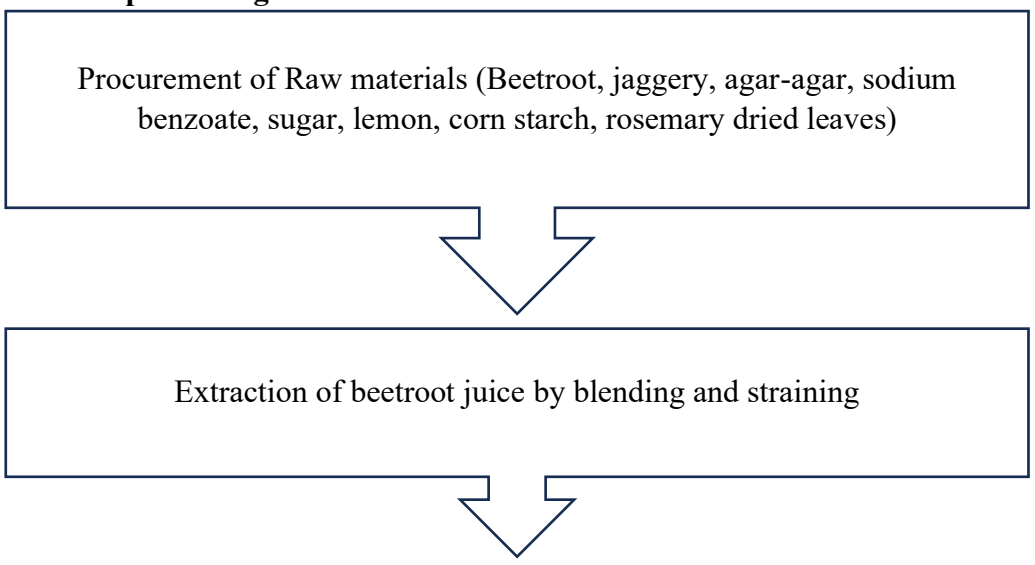
Phase 2 consisted of the following analyses:

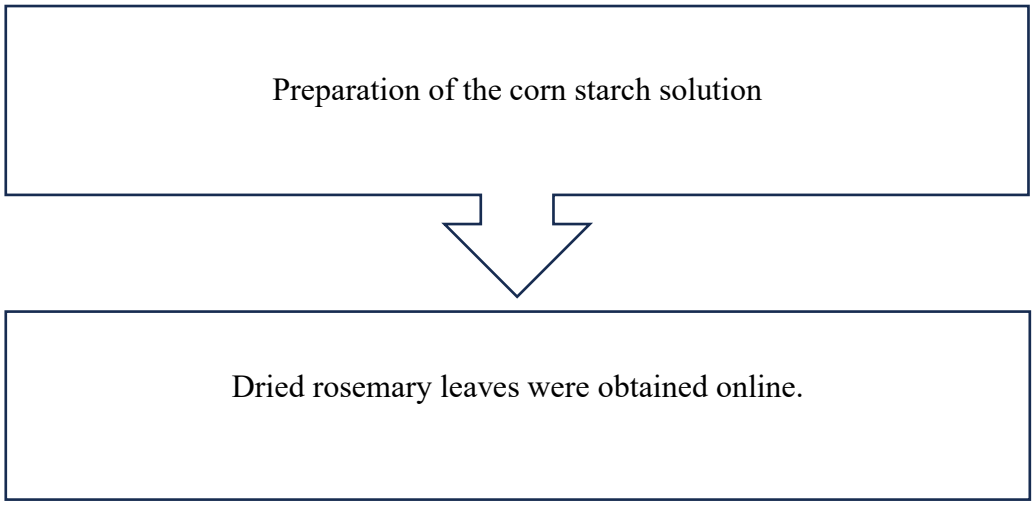
- Analysis of total sugar and micronutrients (iron and vitamin C)
- Statistical analysis
- Costing, packaging, and labeling.

2.4 Development of the product:

This study aimed to develop an iron-enriched nutraceutical. Because of its growing popularity, gummies, a popular chewable candy, were chosen as a standard to be augmented with ingredients that have been scientifically proven to be effective in the treatment of iron deficiency anemia. The product development steps are listed below. The ingredients came from a local market in Bangalore.

2.4.1 Collection and processing of raw materials:





2.4.2 Method of Preparation :

A. Preparation of the standard

- Corn starch solution was prepared and heated at 70 ^{0}C. Measured amounts of beetroot juice, sugar solution, and sodium benzoate were poured simultaneously with a continuous stir.
- After 15 minutes the mixture was gelatinized and agar-agar solution was added along with a continuous stir for another 15 minutes.
- The prepared mixture was allowed to cool down for 5 minutes and lemon juice was added.
- After a thorough stir the solution was transferred in pre-cooled silicon molds and left at room temperature for 3 hours.
- After 3 hours, the gummies were removed from the molds and kept in the dehydrator for 4 hours to give the texture.

B. Preparation of the Variations

- Corn starch solution was prepared and heated at 70 ^{0}C. Measured amounts of beetroot juice, jaggery solution, and sodium benzoate were poured simultaneously with a continuous stir.
- After 15 minutes, the mixture was gelatinized, agar-agar solution was added, and rosemary decoction in different amounts was stirred continuously for another 15 minutes.
- The prepared mixture was allowed to cool down for 5 minutes and lemon juice was added.
- After a thorough stir the solution was transferred in precooled silicon molds and left at room temperature for 3 hours.
- After 3 hours, the gummies were removed from the molds and kept in the dehydrator for 4 hours to give the texture**.**

2.4.3 Formulation of the product:

Table 2.4.3.1: Formulation of gummies as per 100 grams

Ingredients	**T-0**	**V-1**	**V-2**	**V-3**
Beetroot Juice	40	40	40	40
Agar- Agar	4	3	3.5	4
Sodium Benzoate	0.5	0.5	0.5	0.5
Corn Starch	23	18	14	14

Jaggery	-	15	15	10
Sugar	30	-	-	-
Lemon Juice	2	2	2	2
Rosemary dried leaves	-	10	25	30
Total	100	100	100	100

[T-0 = standard gummies, V-1= variation 1, V-2 = variation 2, V-3 = variation 3]

Table 2.4.3.2: Formulation of gummies as per 4 grams

Ingredients	**T-0**	**V-1**	**V-2**	**V-3**
Beetroot juice	1.6	1.6	1.6	1.6
Agar- Agar	0.16	0.12	0.14	0.16
Sodium Benzoate	0.02	0.02	0.02	0.02
Corn Starch	0.88	0.88	0.64	0.64
Jaggery	-	0.6	0.6	0.4
Sugar	1.2	-	-	-
Lemon juice	0.08	0.08	0.08	0.08
Rosemary dried leaves	-	0.4	1	1.2
Total	4	4	4	4

[T-0 = standard gummies, V-1= variation 1, V-2 = variation 2, V-3 = variation 3]

2.5 Sensory evaluation

A 9-point hedonic scale was used to conduct the sensory evaluation. This scale has the following potential advantages over the traditional hedonic scale: (4)

- Potential increase in the scale's discriminative power
- Reduction of the psychological error of habit
- Encouragement of consumers to perform their assessment as consciously and carefully as possible.
- Fewer contextual effects favoring its use in intercultural studies, and
- Use of a variety of parametric and nonparametric statistical analysis because this scale generates continuous.

The scale helped to analyze consumer acceptability on the following attributes- appearance, flavor/taste, aroma, color texture, and overall acceptability. 30 trained and semi-trained panelists conducted the sensory evaluation. Gummies were analyzed based on these 9 attributes. Food product development and market launch require some indication of whether the products are liked or not. Several metrics of like have been examined. However, one of the most well-known measures of like is the 9-point hedonic scale. The scale consists of nine linguistic categories ranging from 'dislike highly' to 'like extremely' and is described as such in sensory publications. For future quantitative and statistical analysis, the verbal categories are typically translated to numerical values: 'like extremely' as '9', 'dislike extremely' as '1' (5).

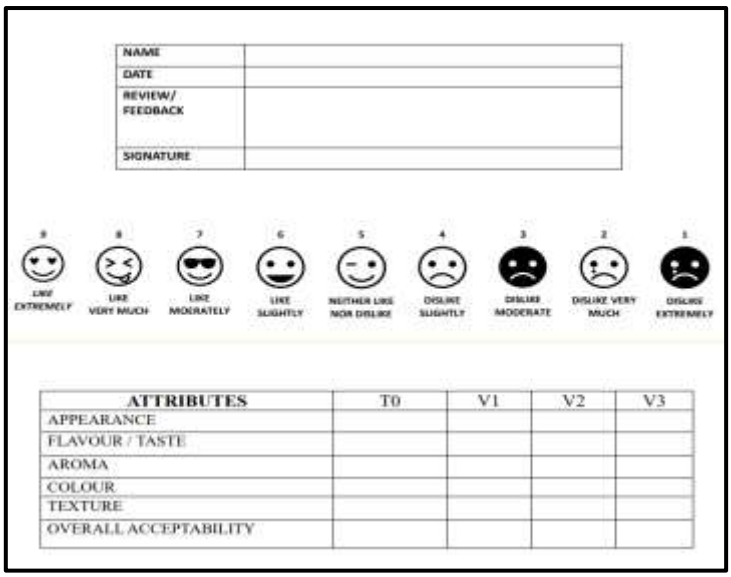


Figure 2.5.1: Sensory Evaluation Sheet

Table 2.5.1: Scoring of 9-Point Hedonic Scale

Scores	Description
1	Like extremely
2	Like very much
3	Like moderately
4	Like slightly
5	Neither like nor dislike
6	Dislike slightly
7	Dislike moderately
8	Dislike very much

2.6 Nutrient analysis:

The following nutritional analyses were conducted for Nutri-gummies.

2.6.1 Total sugar

Carbohydrates have a key role in plant storage and structure. They exist in both free sugars and polysaccharides. The basic units of carbohydrates are monosaccharides, which cannot be hydrolyzed into simpler sugars. To determine carbohydrate content, polysaccharides are hydrolyzed into simple sugars using acid, and the resulting monosaccharides are estimated.

Thus the method conducted for the nutrient analysis of total sugar was (Biochemical method by S Sadasivam A Manickam, 2008)

- 100 mg of the sample was weighed into a boiling tube
- It was hydrolyzed by keeping it in boiling water for three hours with 5ml of 2.5 N-HCL and cooled at room temperature
- It was neutralized with solid sodium carbonate until the effervescence ceases
- The volume was made up to 100ml and was centrifuged
- The supernatant was collected and aliquots of 0.5 and 1ml were taken was analysis

- The standards were prepared by taking 0, 0.2,0.4, 0.6, 0.8, and 1ml in all the tubes including the sample tubes by adding distilled water
- Then 4 ml of enthrone reagent was added
- It was heated for eight minutes in a boiling water bath
- It was cooled rapidly and read the green to dark green color at 630nm
- A standard graph was drawn by plotting the concentration of the standard on the X-axis versus absorbance on the Y-axis
- From the graph, the amount of carbohydrate present in the sample tube was calculated

2.6.2 Iron (AOAC, 2016)

Iron requirements increase during the adolescent period with the initiation of menstruation in females. The requirement of iron is increased if there is a high blood loss, more than the usual in cases of dysmenorrhea, or hypermenorrhea. Iron is also needed for the formation of hemoglobin and the absence of which can lead to severe anemia. Since green tea is deficient in iron content, the developed product is enriched with ingredients that impart iron. Thus, it is important to estimate the amount of iron provided by the product to prove it is beneficial for menstrual disorders.

- 2 g of the sample was ashed by ignition and 5 ml of hydrochloric acid was added.
- The volume was made up to 100 ml in a volumetric flask.
- Different aliquots of the standard solution (1 ml - 5 ml) were taken, corresponding to 10- 50 gamma in a series of test tubes.
- 1 ml of 30% H_2So_4, 1 ml of potassium persulphate, and 1.5 ml of potassium thiocyanate were added to all the test tubes.
- This was made up of 10 ml of distilled water.
- The color was allowed to develop for 20 minutes and the intensity was read at 540nm in the colorimeter against a blank.

2.6.3 Vitamin C (AOAC, 2016)

Vitamin C, also known as ascorbic acid, is involved in the absorption of iron and enhancing the immune system. Vitamin C can boost the estrogen levels and lower progesterone levels thereby causing the uterus to contract and the lining of the lower to break down, leading to the onset of menstruation. Hence it is beneficial for those who suffer from oligomenorrhea or hypomenorrhea. Vitamin also plays a part in regulating hemoglobin levels in the blood. Thus, the developed product is analyzed for vitamin C content through titration method using potassium ascorbic acid standard and 2,6- dichlorophenol indophenol dye.

- Standard ascorbic acid was prepared and the sample was titrated against it.
- 5g of the sample was weighed and soaked in 4% oxalic acid for 10 minutes and then ground and transferred into a centrifuged tube adding more oxalic acid.
- The solution was centrifuged and the supernatant was transferred to a 100ml volumetric flask.
- This extraction was repeated with oxalic acid for 3-4 times.
- All the supernatant was collected in the same volumetric flask and this was finally made up to mark with oxalic acid.
- The dye was taken in a burette and titrated against 5ml of the extract in a conical flask.
- The endpoint was the appearance of pink color.

2.7 Statistical analysis

The results of the study were statistically analyzed to determine the p-value and correlation to formulate tables and graphs. The results were interpreted using ANOVA (Analysis of Variance) in Microsoft Excel. The analysis was performed with a 95% confidence level ($p<0.05$) for both the control and produced products. Based on ANOVA, the highest rating and most acceptable product are established.

2.7.1 Analysis of Variance:

Analysis of variance is a statistical technique that is used to measure the significant difference in the means among different groups/treatments. The test statistic used in this situation is the ' F ' test.

Source of variation	Degrees of freedom (df)	Sum of Squares (SS)	Mean sum of squares (MSS)	'F' Test
Treatment	t-1	TrSS	TrSS/ t-1	
Error	N-t	ESS	ESS/ N-t	-
total	N-1	TSS	-	-

Table 2.7.1.1 Analysis of Variance

3. Results

The study aimed to develop gummies with iron-enriched ingredients and to develop it in a way to increases iron absorption in the body as well. Three variations were made using different formulation quantities of the enriching ingredients. It has been found from various studies that the ingredients used in the gummies are beneficial for increasing iron stores in the body as well as helping in absorbing iron present or consumed from various sources as well.

3.1 Consumer preference survey

The present study involved a consumer preference survey aimed at gathering data regarding the awareness of gummies among the targeted population (13-45 years of age), as well as their consumption patterns of gummies available in the market. The survey was instrumental in analyzing the diverse reasons for their consumption, their opinion on the formulation of gummies currently available in the market, and several other aspects that helped to design a product that is more aligned with consumers' preferences.

3.1.1 General information of the respondents

Table 3.1.1.1: Demographic data of the respondents

Characteristics	Category	Respondents	
		Number (n)	Percent (%)
Age group (years)	15-20	10	15.2 %
	20-30	33	50 %
	30-40	13	19.7 %
	40-50	10	15.2 %
	Total	**66**	**100.0**
Sex	Male	29	43.9 %
	Female	37	56.1 %
	Prefer not to say	-	-
	Total	**66**	**100.0**

Occupation	Employed	35	53 %
	Student	28	42.4 %
	House maker	3	4.5 %
	Total	**66**	**100.0**

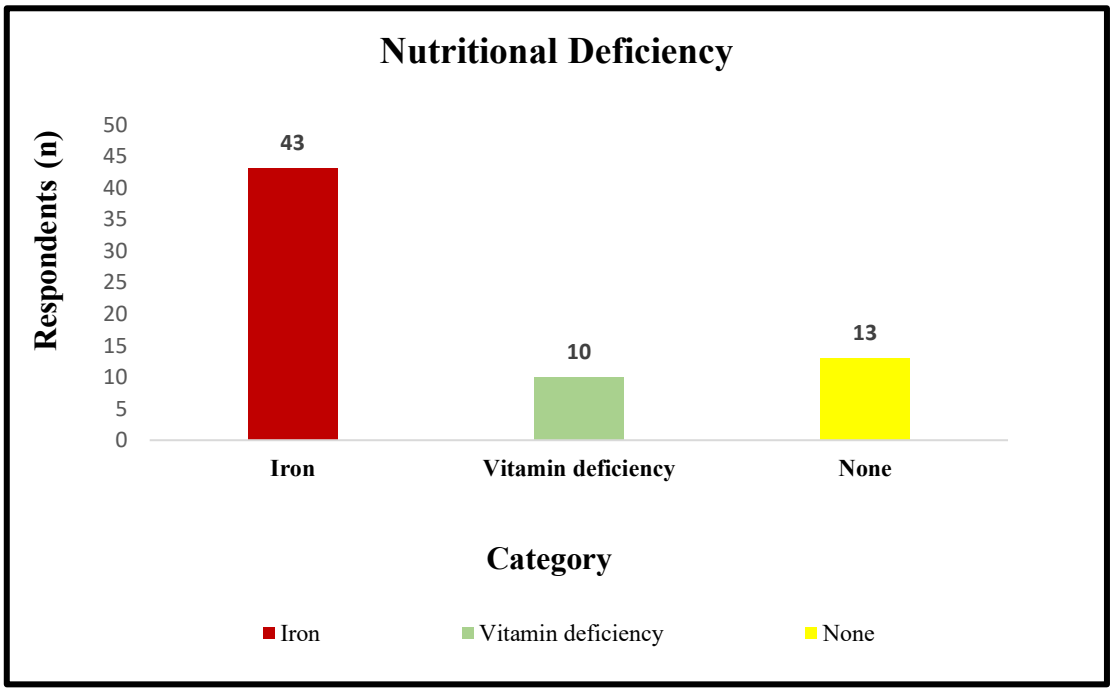


Figure 3.1.1: Responses on Nutritional Deficiency

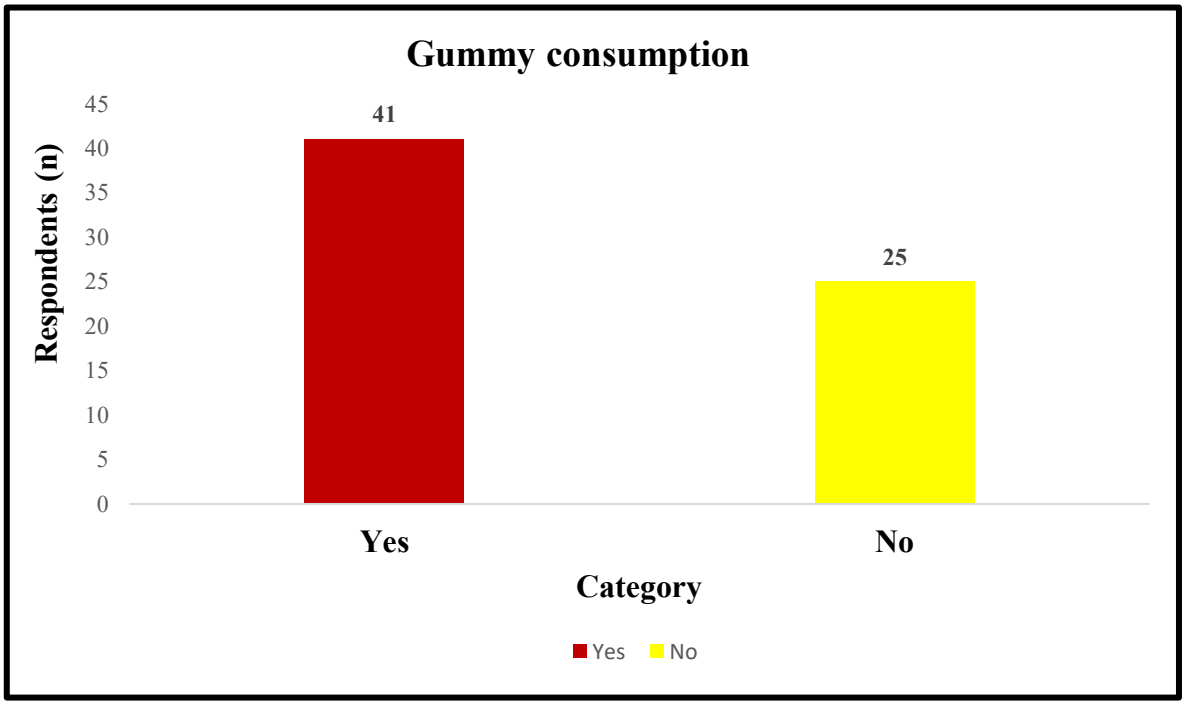


Figure 3.1.2: Responses on Gummy Consumption

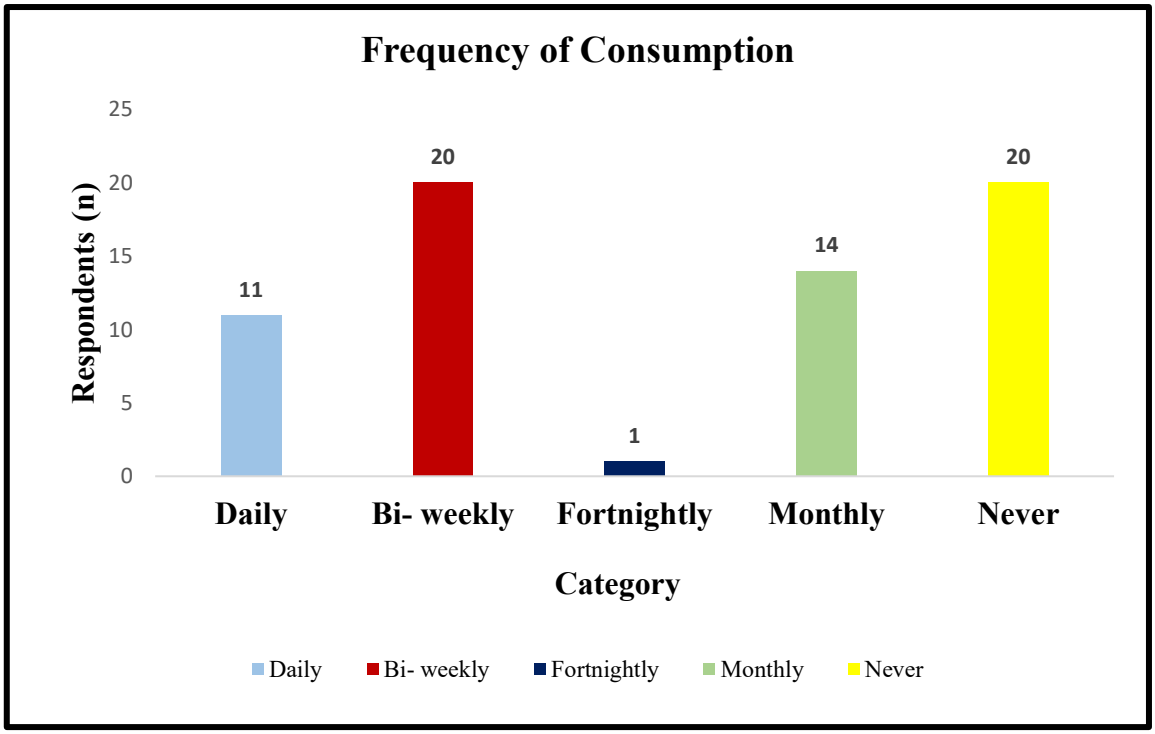


Figure 3.1.3: Responses on Frequency of Consumption

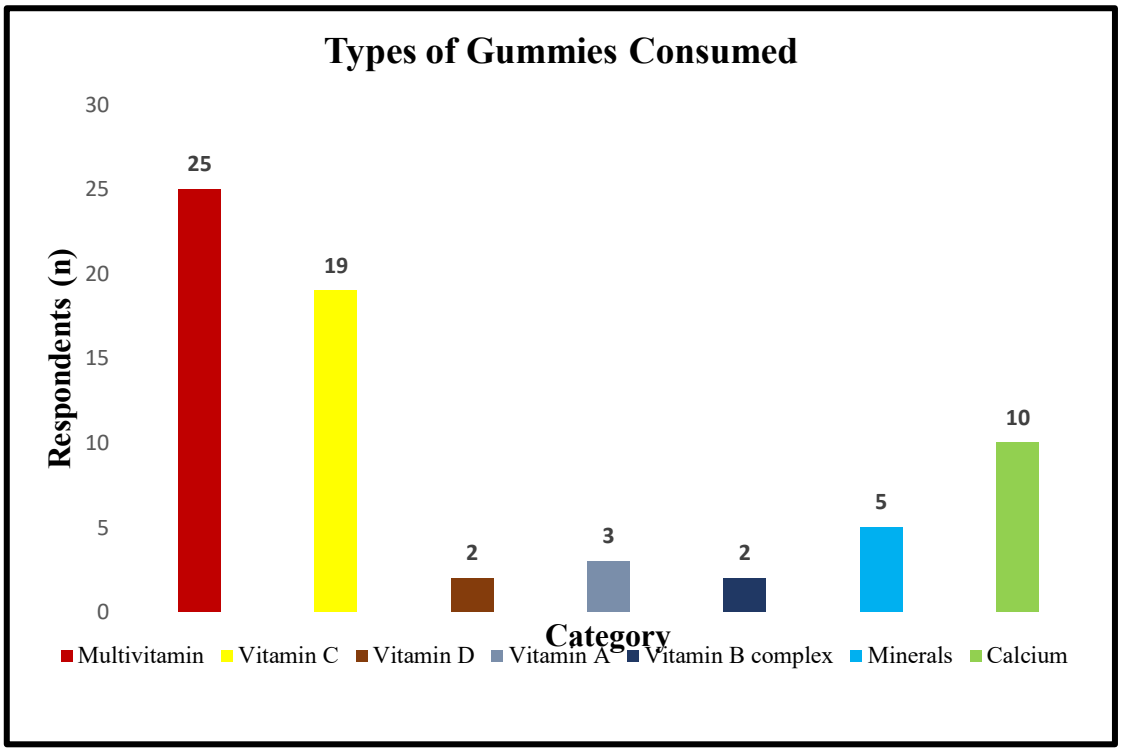


Figure 3.1.4: Responses on type of gummies consumed

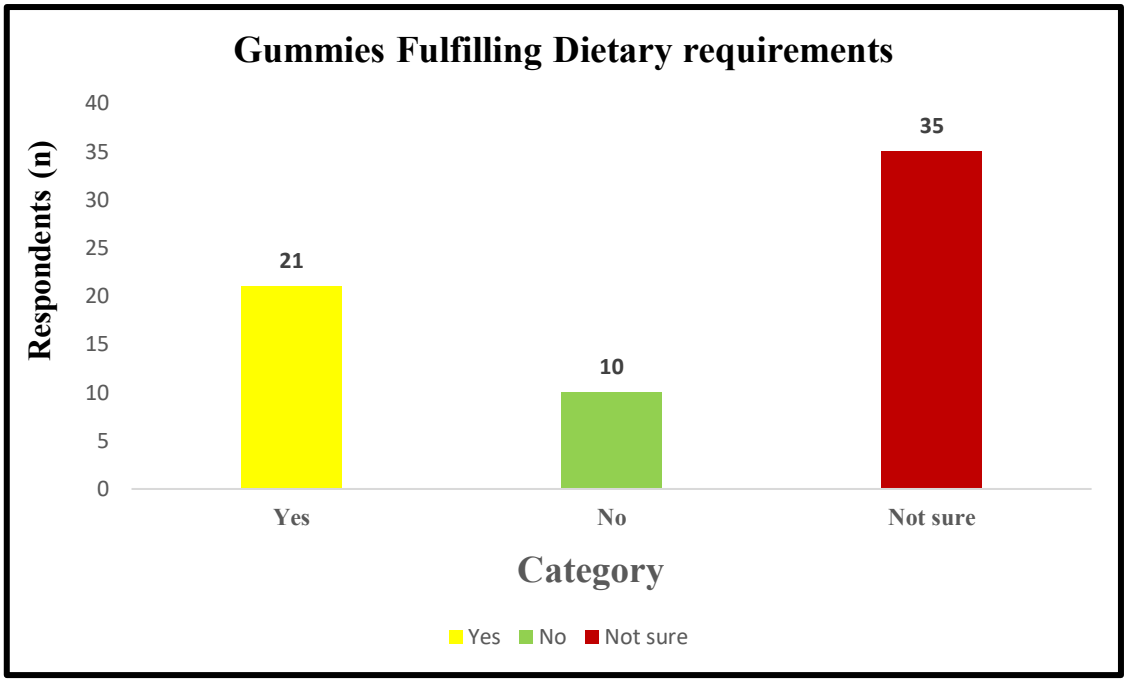


Figure 3.1.5: Responses on gummies fulfilling dietary requirements

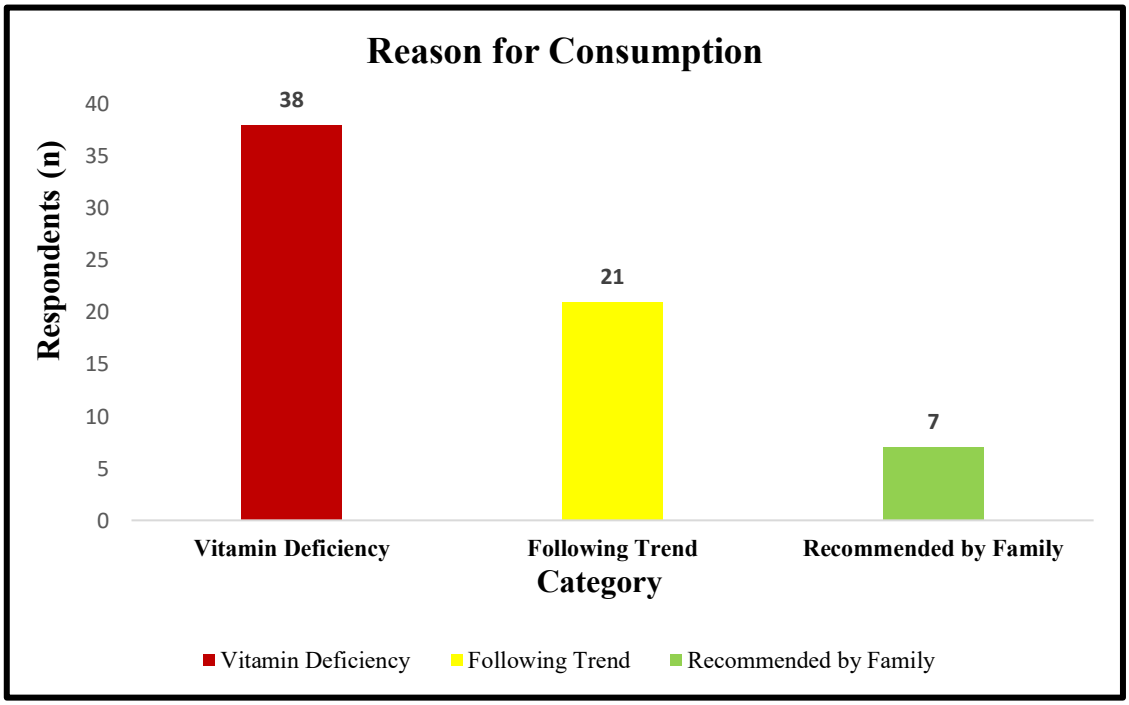


Figure 3.1.6: Responses on the reason for consumption

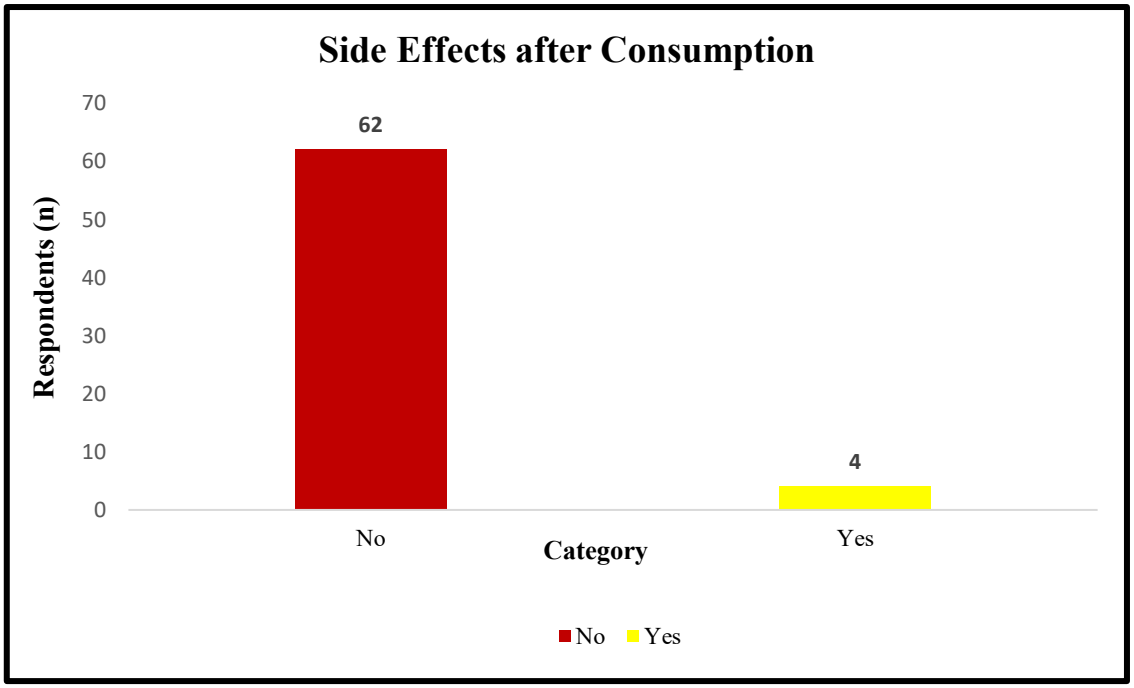


Figure 3.1.7: Responses on side effects after consumption

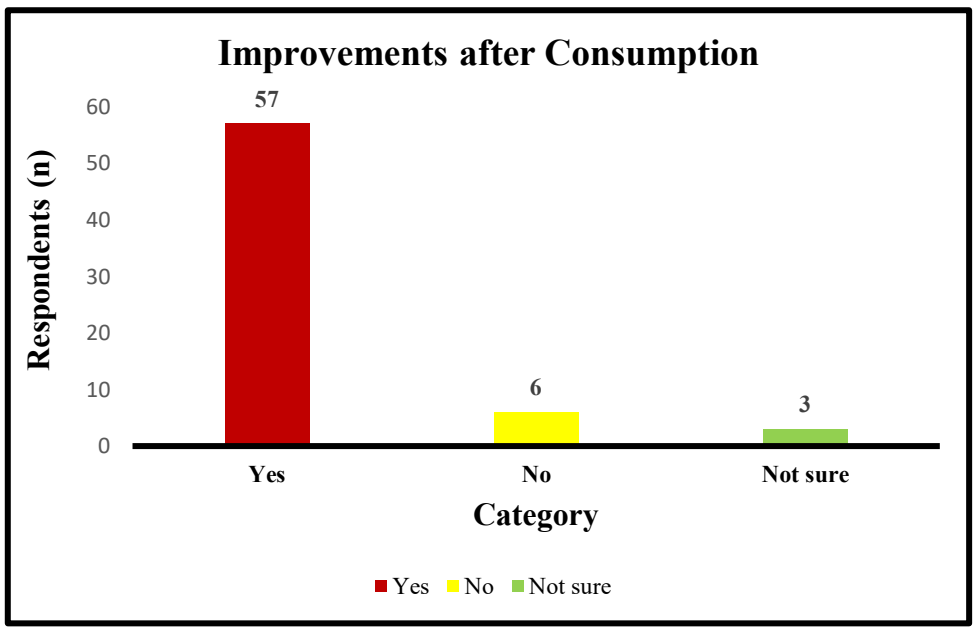


Figure 3.1.8: Responses on improvements after consumption

Table 3.1.2: Correlation between the presence of nutritional deficiencies and consumption of gummy vitamins

	Nutritional deficiencies	Gummy Vitamin Consumption
Nutritional deficiencies	1	-0.029718765
Gummy vitamin consumption	-0.029718765	1

Table 3.1.2 depicts a significant negative correlation between the presence of nutritional deficiencies and the consumption of gummy vitamins. It signifies that respondents who have a deficiency of nutrients are found to have more gummy vitamin consumption.

3.2 Formulation of Iron-Enriched Gummies

Table 3.2.1: Formulation of Therapeutic Gummies

Ingredients	T-0	V-1	V-2	V-3
Beetroot juice	1.6	1.6	1.6	1.6
Agar- Agar	0.16	0.12	0.14	0.16
Sodium Benzoate	0.02	0.02	0.02	0.02
Corn Starch	0.88	0.88	0.64	0.64
Jaggery	-	0.6	0.6	0.4
Sugar	1.2	-	-	-
Lemon juice	0.08	0.08	0.08	0.08
Rosemary dried leaves	-	0.4	1	1.2
Total	4	4	4	4

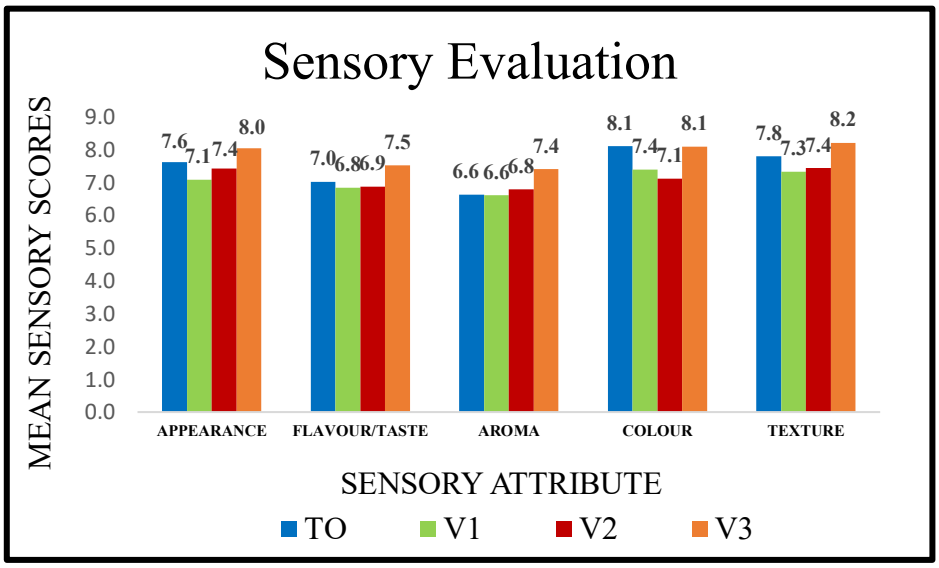
[T-0 = standard gummies, V-1= variation 1, V-2 = variation 2, V-3 = variation 3]

3.3 Sensory evaluation of the formulated product

Table 4.3.1: Sensory scores of therapeutic gummies

[T-0 = standard gummies, V-1= variation 1, V-2 = variation 2, V-3 = variation 3]

PARAMETERS	PRODUCTS				
	T-O	V-1	V-2	V-3	P- VALUE
Appearance	7.6	7.1	7.4	8.0	0.005
Flavor	7.0	6.8	6.9	7.5	
Aroma	6.6	6.6	6.8	7.4	
Color	8.1	7.4	7.1	8.1	
Texture	7.8	7.3	7.7	8.2	
Overall Acceptability	7.8	7.1	7.2	7.9	



[T-0 = standard gummies, V-1= variation 1, V-2 = variation 2, V-3 = variation 3]

Figure 3.3.1: Sensory Evaluation of Therapeutic Gummies

3.4 Nutrient Analysis

Table 3.4.1: Nutrient Analysis

Sl. No.	Test Parameter	Results mg/100g
1.	Iron	17
2.	Vitamin C	55.3
3.	Total Sugar	395

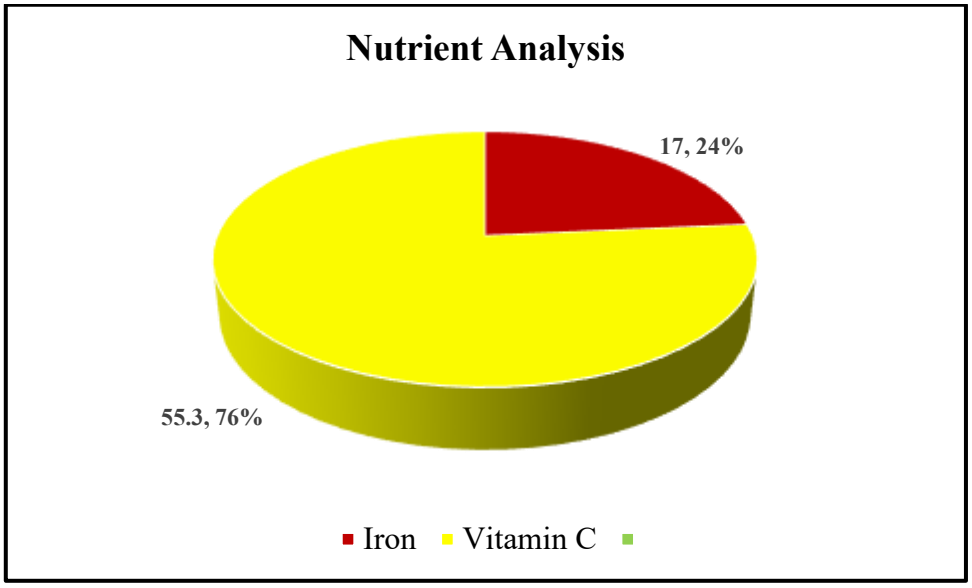


Fig 3.4.1: Nutrient Analysis of Iron and Vitamin C

3.5 Statistical Analysis

3.5.1 Analysis of Variance:

Analysis of variance is a statistical technique that is used to measure the significant difference in the means among different groups/treatments. The test statistic used in this situation is the ' F ' test.

Source of variation	Degrees of freedom (df)	Sum of Squares (SS)	Mean sum of squares (MSS)	'F' Test
Treatment	t-1	TrSS	TrSS/ t-1	
Error	N-t	ESS	ESS/ N-t	-
total	N-1	TSS	-	-

Table 3.5.1.1 Analysis of Variance

4. CONCLUSION

To begin, the formulation process emphasized the need to select appropriate chemicals and adjust their concentrations to achieve efficacy and palatability simultaneously. Balancing iron content to satisfy dietary recommendations. Furthermore, the use of complementary nutrients like vitamin C to improve iron absorption demonstrates the diverse approach required for optimal micronutrient supplementation.The

qualitative analysis phase yielded crucial information on the sensory properties, consumer acceptance, and prospective enhancements for the iron-enriched gummies. Sensory evaluation panels clarified impressions of flavor, texture, and overall experience. It was useful to determine the best variation preferred by consumers, which was variation three. The consumer preference survey provided insight into customer knowledge and usage of gummies. This feedback loop supports the formulation technique while also providing actionable data for future modification and customization to better fit customer preferences. Furthermore, the qualitative examination went beyond sensory features and included broader factors like packaging, labeling, and pricing tactics. Understanding consumer attitudes and preferences in these areas is critical to ensure the successful adoption and long-term use of iron-enriched gummies in target populations. To summarize, the development and qualitative analysis of iron-enriched gummies make an important contribution to nutritional research and public health. This study has shed light on approaches to treat the widespread problem of iron insufficiency by taking a holistic strategy that includes formulation improvement, sensory evaluation, and consumer preference research. As we move forward, more research, collaboration, and innovation will be required to fully realize the promise of fortified food items to enhance global health and well-being.

5. Acknowledgement

With the completion of this dissertation, I feel forced to express my heartfelt gratitude to those whose contributions have been valuable to my academic journey. I would want to convey my profound gratitude to The School of Allied Healthcare and Sciences at Jain (Deemed-to-be-University), for providing me with the chance to conduct rigorous research and exceed my expectations. Recognizing the pivotal role of financial support, I extend my deepest gratitude to my parents, Mr. Pawan Kumar Saini and Mrs. Rajesh Kumari, whose unwavering encouragement and assistance have been instrumental in realizing our collective aspirations.

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