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# DEVELOPMENT AND SENSORY EVALUATION OF IRON CANDY: A FUNCTIONAL FOOD APPROACH TO COMBAT IRON DEFICIENCY

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## ABSTRACT

**Background:** Iron deficiency anemia (IDA) remains one of the most widespread nutritional deficiencies globally, particularly in adolescents, women of reproductive age, and children. Conventional iron supplements often face challenges such as poor taste, side effects, and low compliance. Developing functional confectionery such as iron-rich candies may provide a palatable, cost-effective, and culturally acceptable solution.

**Objective:** This study aimed to develop iron-enriched candies using natural ingredients—jaggery, beetroot, and orange—and to evaluate their sensory acceptability across different age groups.

**Methods:** Two formulations of iron candy were developed: Sample 1 (orange-rich) and Sample 2 (beetroot-rich), both using jaggery as a base. Thirty participants (10 adolescents, 10 adults, 10 elderly) assessed sensory attributes—colour, mouthfeel, texture, appearance, flavour, and overall acceptability—using a 9-point hedonic scale. Data were analyzed using descriptive statistics and interpreted in light of relevant studies.

**Results:** Both formulations were well accepted, though preferences varied by age group. Adolescents preferred the orange-rich formulation for its brighter colour and smoother mouthfeel, while adults leaned toward the beetroot-rich version for its distinctive flavour. Elderly participants favored the softer texture of the beetroot-rich candy. Overall acceptability was high across all groups, with mean scores ranging between 6.4 and 7.9.

**Conclusion:** Iron-enriched candies combining jaggery, beetroot, and orange demonstrated good sensory acceptance across age groups. Their development offers a promising, consumer-friendly strategy to address iron deficiency through functional foods.

**Keywords:** Iron Deficiency Anemia, Functional Foods, Sensory Evaluation, Jaggery, Beetroot, Orange, Iron Candy.

## 1. INTRODUCTION

Iron deficiency anemia (IDA) is the most prevalent nutritional disorder worldwide, affecting approximately 1.9 billion people and contributing significantly to the global burden of disease (WHO, 2023). IDA results from insufficient iron intake, impaired absorption, or increased physiological demands, and is particularly prevalent among women of reproductive age, adolescents, and children. According to the Global Burden of Disease Study (Kassebaum et al., 2014), nearly half of all anemia cases are attributed to iron deficiency, which underscores the urgent need for sustainable, food-based interventions. In India, the prevalence of anemia continues to be alarmingly high, with the National Family Health Survey (NFHS-5, 2021) reporting that more than 57% of women aged 15–49 years and 67% of children under five are anemic. This widespread prevalence highlights anemia as not only a medical issue but also a socio-economic and developmental challenge.

Iron plays a crucial role in hemoglobin synthesis and oxygen transport, making it indispensable for normal growth, cognitive development, physical performance, and immunity (Camaschella, 2015). Its deficiency manifests in fatigue, weakness, impaired learning ability, reduced immunity, and in severe cases, maternal and perinatal complications. Adolescents, in particular, are highly vulnerable due to rapid growth spurts, menstruation in females, and often inadequate dietary intake. Anemia during adolescence can have long-term consequences, including reduced academic performance, lower work productivity, and impaired reproductive health in adulthood (Zimmermann & Hurrell, 2007).

Efforts to combat anemia traditionally involve iron supplementation in the form of tablets, capsules, or syrups. While clinically effective, these supplements are often associated with poor compliance due to unpleasant taste, gastrointestinal side effects, and lack of awareness or motivation (Hurrell, 2017). Compliance rates in large-scale programs have been reported as low as 30–40%, limiting the success of supplementation strategies (Palacios et al., 2016). This has led to growing interest in food-based interventions and functional foods as sustainable alternatives.

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Functional foods are designed to provide additional health benefits beyond basic nutrition, and their development aligns with consumer preferences for natural, convenient, and palatable products.

In this context, confectionery items such as candies and lozenges are being increasingly explored as carriers of micronutrients. Fortified candies offer several advantages: they are widely acceptable among children and adolescents, inexpensive, easy to distribute, and can be consumed without the stigma often associated with medicines. Studies from Indonesia (Sari et al., 2001) and India (Mamatha & Prakash, 2016) have demonstrated that iron-fortified candies not only improved hemoglobin levels but also achieved high sensory acceptability. These findings suggest that confectionery-based interventions could complement existing anemia control strategies.

Jaggery, beetroot, and orange were selected in this study as key ingredients for developing iron-rich candies. Jaggery is a traditional Indian sweetener that retains essential minerals, including iron, magnesium, and potassium, unlike refined sugar (Goyle et al., 2012). Its widespread cultural acceptance makes it an ideal base for functional confectionery. Beetroot is a natural source of iron, folate, and antioxidants, and previous studies have highlighted its role in enhancing hemoglobin levels (Clifford et al., 2015). Orange, on the other hand, is rich in vitamin C, which significantly improves the bioavailability of non-heme iron from plant sources (Hallberg et al., 1989). The synergistic combination of these ingredients not only enhances the nutritional value but also improves the sensory properties, making the product more appealing.

The concept of sensory evaluation is crucial in functional food development. Consumer acceptability determines the success of any fortified product, regardless of its nutritional profile. Attributes such as colour, texture, flavour, and mouthfeel strongly influence consumer preferences and compliance (Ventura & Worobey, 2013). By conducting sensory evaluation across diverse age groups, this study seeks to determine whether iron-fortified candies are acceptable to different demographic segments, thereby ensuring their potential for wide-scale implementation.

In summary, the development of iron-fortified candies addresses multiple challenges associated with anemia control: it provides a culturally relevant, palatable, and nutrient-dense product that can be consumed without resistance. Unlike conventional supplements, fortified candies integrate nutrition into daily dietary practices, making them more sustainable. Thus, the present study was designed with the following objectives: (1) to develop iron-rich candies using jaggery, beetroot, and orange; (2) to evaluate their sensory attributes across different age groups; and (3) to analyze acceptability patterns in relation to consumer preferences. This approach contributes to the growing body of literature on functional foods and offers an innovative strategy to complement national programs aimed at reducing anemia prevalence in India.

## 2. MATERIALS AND METHODS

This study adopted an experimental research design, which involves manipulation of variables under controlled conditions to examine their effects. The focus of the present research was on the development, formulation, and sensory evaluation of iron-fortified candies. The methodology encompassed product formulation, preparation, and sensory testing to assess consumer acceptability of the developed candies.

The central hypothesis guiding the research was that the developed iron candy would be acceptable to consumers. The locale of the study was Mizoram, where participants were selected to represent a broad demographic, including adolescents, adults, and elderly individuals. This setting allowed the researchers to capture diverse consumer preferences and perceptions of fortified confectionery.

The development of iron candy was carried out in multiple stages. Two formulations were prepared using selected natural ingredients—Sample 1 (IC1) and Sample 2 (IC2)—with varying proportions of orange and beetroot juice. Jaggery, known for its mineral content and cultural acceptability, was used as the base sweetener to bind the candy and provide natural iron. Sample 1 (IC1) consisted of 200 ml of jaggery, 100 ml of orange juice, and 50 ml of beetroot juice. This formulation provided a tangier flavour and higher vitamin C content, supporting iron absorption. In contrast, Sample 2 (IC2) contained 200 ml of jaggery, 100 ml of beetroot juice, and 50 ml of orange juice, offering a deeper colour and higher natural iron content. This dual-sample approach was adopted to explore differences in taste, appearance, and nutritional contribution, while enabling comparison of acceptability across age groups.

The ingredients chosen for candy preparation were locally available and nutrient-rich: jaggery derived from sugarcane juice (as the base sweetener and source of minerals), orange juice (a source of vitamin C to enhance iron absorption), and beetroot juice (a natural source of iron and folate, also contributing colour). Fresh orange and beetroot were juiced separately and combined with the constant base of jaggery. The mixture was boiled for 30 minutes to 1 hour with continuous stirring until a candy-like consistency was achieved. While hot, the mixture was poured onto a greased iron plate, shaped into candies, cooled, and packed for evaluation.

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For sensory evaluation, 30 individuals were selected as evaluators, consisting of 10 adolescents, 10 adults, and 10 elderly participants. This diverse panel allowed for analysis of consumer preferences across different life stages. Sensory attributes including colour, texture, flavour, mouthfeel, appearance, and overall acceptability were evaluated using the 9-point hedonic scale (1 = dislike extremely, 9 = like extremely). This scale is widely used in sensory studies to quantify consumer perception of food products, providing both objectivity and comparability.

Evaluation procedures were standardized to minimize bias. Samples were coded before being presented to participants under controlled conditions. Each evaluator tasted both formulations and provided ratings for all sensory attributes using structured sensory evaluation forms. The data collected were compiled and analyzed descriptively to calculate mean scores and identify trends in acceptability across groups.

## 3. RESULTS

**Table 1:** Demographic Profile of Evaluators (N = 30)

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Age Group | Adolescents | 10 | 33.3 |
| | Adults | 10 | 33.3 |
| | Elderly | 10 | 33.3 |
| Gender | Male | 12 | 40.0 |
| | Female | 18 | 60.0 |
| Dietary Preference | Vegetarian | 15 | 50.0 |
| | Non-vegetarian | 9 | 30.0 |
| | Eggetarian | 6 | 20.0 |

The demographic distribution ensured equal representation across age groups, with a slightly higher proportion of female participants (60%). A balanced mix of dietary preferences allowed the study to capture varied perspectives, aligning with guidelines for sensory panel diversity (Meilgaard et al., 2016).

**Table 2:** Product Characteristics of Iron Candy Samples

| Feature | IC1 (Orange-rich) | IC2 (Beetroot-rich) |
|---|---|---|
| Colour | Bright reddish-orange | Deep reddish-purple |
| Taste | Tangy, fruity | Earthy, mildly sweet |
| Texture | Firm, chewy | Softer |
| Nutrients | Higher vitamin C | Higher natural iron |

IC1 was richer in vitamin C due to higher orange content, supporting non-heme iron absorption (Hallberg et al., 1989). IC2 provided more iron from beetroot, making it suitable for adults and elderly populations requiring higher mineral intake. The contrasting colour and texture allowed evaluators to clearly distinguish between formulations.

**Table 3:** Sensory Scores of Iron Candy Samples (Mean ± SD)

| Attribute | Adolescents (IC1 / IC2) | Adults (IC1 / IC2) | Elderly (IC1 / IC2) |
|---|---|---|---|
| Colour | 7.5 ± 0.8 / 7.1 ± 0.6 | 7.9 ± 0.7 / 7.8 ± 0.6 | 7.4 ± 0.5 / 7.4 ± 0.7 |
| Mouthfeel | 7.8 ± 0.9 / 7.1 ± 0.8 | 7.4 ± 0.6 / 7.1 ± 0.7 | 6.7 ± 0.7 / 7.0 ± 0.8 |
| Texture | 7.5 ± 0.7 / 6.6 ± 0.6 | 7.0 ± 0.5 / 6.8 ± 0.7 | 5.3 ± 0.6 / 6.1 ± 0.8 |
| Appearance | 7.5 ± 0.6 / 7.7 ± 0.5 | 7.8 ± 0.7 / 7.6 ± 0.6 | 7.4 ± 0.8 / 7.8 ± 0.7 |
| Flavour | 7.3 ± 0.8 / 7.2 ± 0.7 | 7.1 ± 0.7 / 7.7 ± 0.8 | 7.1 ± 0.5 / 6.8 ± 0.6 |
| Overall Accept. | 7.6 ± 0.6 / 7.1 ± 0.7 | 7.0 ± 0.8 / 7.2 ± 0.6 | 6.4 ± 0.7 / 6.8 ± 0.5 |

Adolescents rated IC1 higher in mouthfeel and texture, showing a preference for tangy and chewy candies. Adults leaned toward IC2 due to flavour complexity, while elderly participants preferred IC2 for its softer texture. These results echo Ventura & Worobey (2013), who reported that flavour familiarity drives adolescent preferences, and Laguna et al. (2016), who emphasized softer textures for elderly acceptability.

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**Table 4:** Comparative Analysis of IC1 vs IC2 Sensory Scores

| Attribute | Adolescents (p-value) | Adults (p-value) | Elderly (p-value) |
|---|---|---|---|
| Colour | 0.21 (NS) | 0.38 (NS) | 0.44 (NS) |
| Mouthfeel | 0.03* | 0.12 (NS) | 0.19 (NS) |
| Texture | 0.02* | 0.17 (NS) | 0.01* |
| Appearance | 0.30 (NS) | 0.41 (NS) | 0.35 (NS) |
| Flavour | 0.29 (NS) | 0.04* | 0.27 (NS) |
| Overall Accept. | 0.04* | 0.18 (NS) | 0.03* |

*Significant at $p < 0.05$; NS = Not Significant

**Interpretation: Interpretation:** Significant differences were observed in adolescents' mouthfeel and texture ratings, where IC1 (orange-rich) was preferred due to its chewy and tangy profile. Adults showed a significant preference for flavour in IC2 (beetroot-rich), reflecting an appreciation for its earthy sweetness and nutritional value. Among elderly participants, IC2 was rated significantly higher for texture and overall acceptability, attributed to its softer consistency that was easier to chew. These findings emphasize that sensory preferences differ across age groups—adolescents favour tangy and chewy candies, while adults and elderly participants prefer products with richer flavour and softer texture. This age-related variation in acceptance is consistent with earlier studies highlighting flavour familiarity in younger populations (Mamatha & Prakash, 2016), increasing adult acceptance of beetroot-based functional foods (Clifford et al., 2015), and the need for texture modification in elderly diets (Laguna et al., 2016).

## 4. DISCUSSION

The present study assessed the sensory attributes and acceptability of two iron-fortified candies—IC1 (orange-rich) and IC2 (beetroot-rich)—across adolescents, adults, and elderly participants. The panel was balanced in age and dietary preferences, with a slight predominance of females (60%), ensuring diverse perspectives and minimizing bias (Meilgaard et al., 2016). IC1, rich in vitamin C from oranges, supports non-heme iron absorption (Hallberg et al., 1989), while IC2, with higher natural iron from beetroot, caters to populations with greater mineral needs. Sensory evaluation revealed age-specific preferences: adolescents favored IC1 for its tangy taste and chewy texture, reflecting their attraction to familiar, intense flavours (Ventura & Worobey, 2013); adults preferred the earthy sweetness and complex flavour of IC2, highlighting the role of nutritional quality in adult acceptability (Clifford et al., 2015); and elderly participants rated IC2 higher for its softer texture, facilitating easier consumption and higher overall acceptability (Laguna et al., 2016). Colour and appearance were generally well-received across all groups, but flavour and texture were key determinants of preference. Statistical analysis confirmed significant differences in adolescents' mouthfeel and texture, adults' flavour, and elderly participants' texture and overall acceptability, emphasizing that sensory optimization should be tailored to age-specific needs to enhance the acceptability of functional iron-fortified candies.

## 5. CONCLUSION

Overall, the study demonstrates that age-related differences in sensory perception and preference significantly influence the acceptability of functional foods. IC1 (orange-rich) is more suitable for adolescent consumers, while IC2 (beetroot-rich) meets the sensory and nutritional needs of adults and elderly populations. These findings highlight the need for targeted formulation strategies in functional confectionery development to improve both consumption and nutritional impact.

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