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RESEARCH ARTICLE

FORMULATION AND EVALUATION OF IRON RICH FOOD SUPPLEMENT FROM GREEN LEAFY VEGETABLES FOR ANAEMIC ADOLESCENT

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ABSTRACT

Green leafy vegetables being the treasure trove of micronutrients finds a place in combating the menace of nutritional anemia. Green leafy vegetables are used since ancient periods as source of food as they contain many nutrients and minerals which are helpful in maintaining human health.

Methodology: Based on the consumption pattern of micronutrient rich foods among the target population (adolescent), three green leafy vegetables namely Araikeerai *(Amaranthus tristis)*, Manathakkali (*Solanumnigrum),* Thandukeerai *(Amaranthus gangeticus)*. In total three variations were formulated using the three different green leafy vegetables along with incorporation of rice flakes, wheat flour, roasted Bengal gram flour, flax seeds and gingelly seeds *(Sesamum indicum)*, and amla. Jaggery (20g) was also added in the formulation. Nutritional and shelf-life evaluation was carried out. Keeping all the ingredients at similar proportions and by varying the types of greens and fruits, three iron rich food formulations were arrived at namely ladoo, porridge and steamed cake. Among these, ladoos prepared were most acceptable and hence using the three variations, ladoos were prepared and were subjected to acceptability trial. Out of the three formulations, variation I in the form of ladoos was found to be the best one in terms of scoring and sensory evaluation. Nutritional and shelf-life evaluation was also carried out.

Results: The mean carbohydrate content of the formulation were 84.7g, iron content 18.83 mg and calcium content was 150.25 mg. The developed supplement also had good shelf life.

Conclusion: Green leafy vegetables are good source of fibre and micronutrients. Multiple micronutrient deficiencies are very common than single deficiency mainly in developing countries. Nutritional problems are more severe; mostly people in the developed countries also suffer from different forms of these nutritional problems. Nutritionists are now trying to encourage people for supplementation of green leafy vegetables in nutritional recipes to combat with these micronutrient deficiencies.

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INTRODUCTION

The health and nutrition of expanding world populations are major upcoming challenges especially in developing countries. Plant foods are sources of energy, micronutrients and nutrients essential to health, in addition to phyto-chemicals with further health benefits including glycemic control, immuno-stimulation or antioxidant activity (Bélanger, 2004). The Expert Committee of the Indian Council of Medical Research (ICMR 2010), taking into consideration the nutrient requirements, has recommended that every individual should consume around 50 g of green leafy vegetables (NIN, 2011). Fruits and vegetables provide essential micronutrients vital for nutrition and health. India is No 1 or 2 in production of vegetables and fruits. Export earning from fruits and vegetables are growing but percapita vegetable and fruit consumption continues to be low in all segments of population including families with no economic constraints. Low vegetable consumption is the major factor responsible for widespread anaemia and micronutrient deficiencies.Nutrition education for increase in vegetable consumption to improve micronutrient status and reduce NCD will succeed only when vegetables are available throughout the year at affordable cost. While dietary change can be challenging, interventions that have included both dietary and behavioral components and have involved the community in the development of the interventions (in terms of cost and local acceptability of iron-rich foods), have shown success on a small scale. They also researched how to present the accompanying educational messages regarding the effects of iron intake on school

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performance in a culturally-appropriate way. As a result, the adolescents receiving the interventions had increased knowledge on which foods to eat to improve iron intake, which was reflected in a greater total daily intake of iron, including a tripling of heme iron intake. Food-based approaches represent the most desirable and sustainable method of preventing micronutrient malnutrition. Such approaches are designed to increase micronutrient intake through the diet. The primary goal of dietary modification to improve and maintain the iron status of a population involves changes in behaviour, leading to an increase in the selection of iron-containing foods and a meal pattern favourable to increased bioavailability. Although sometimes difficult to achieve, such changes in dietary habits can bring about important sustainable improvements, not only in iron status but also for nutrition in general. Such changes must be rooted in issues that take into account food security, actual availability, and education (Maurice *et al*., 2007). Multiple approaches including nutrient supplementation, food fortification, diversification and public health measures have been suggested for prevention and control of nutritional deficiencies (Zhou *et al*., 2009). Dietary improvement becomes the most logical and sustainable strategy to prevent micronutrient deficiencies. Improving the diet is of paramount importance since it contributes to improvement in the overall nutritional status. From the various methods to combat micronutrient deficiencies, dietary supplementation with micronutrient rich foods was chosen as the next phase of the present study.

MATERIALS AND METHODS

Selection of Ingredients

Development of Micronutrient Rich Food Products

Based on the iron content of foods, commonly consumed iron rich foods like rice flakes, wheat flour, roasted Bengal gram flour, flax seeds and gingelly seeds *(Sesamum indicum)*, green leafy vegetables and jaggery were chosen for the development of micronutrient rich formulation. Based on the consumption pattern of micronutrient rich foods among the target population (adolescent), three green leafy vegetables namely Araikeerai *(Amaranthus tristis)* (5g), manathakkali (*Solanum nigrum) (*5g) thandukeerai *(Amaranthus* gangeticus) (5g) and amla (5g) were selected. Other foods rich in iron were selected based on the ease of procurement and acceptability. The other ingredients selected included rice flakes (25g), wheat flour (10g), roasted Bengal gram flour (20g), gingelly seeds (5) and flax seeds (10g), were roasted and powdered. Green leafy vegetables were cleaned, washed, oven dried and powdered. In total three variations were prepared using the three different green leafy vegetables. Jaggery (20g) was also added in the formulation (Fig 1). Three green leafy vegetables with high iron content namely araikeerai *(Amaranthus tristis*), manathakkali *(Solanum nigrum),* and Thandu keerai *(Amaranthus gangeticus)* with a very rich source of iron content along with micronutrient rich fruits like amla, were selected for the development of iron rich food formulations. Keeping all the ingredients at similar proportions and by varying the types of greens and fruits, three iron rich food formulations were arrived at namely ladoo, porridge and steamed cake. Among these products prepared, ladoos were most acceptable and hence using the three variations ladoos was prepared for adolescent and women based on their respective formulations. The various food ingredients chosen for the preparation of ladoo along with their quantities are listed

A) Preparation of Iron rich food supplement

The food ingredients chosen for the preparation comprised of all the important food groups namely, cereal, pulse, green leafy vegetables and fruits.

B) Processing of Ingredients

The dry ingredients were procured from commercial market and cleaned manually by sieves and winnows. The cereals millets, pulses and seeds were roasted in a dry pan individually at a temperature between 60 to 90^0 C for duration of fifteen minutes.

1. Roasting

The dry ingredients were roasted in a pan (without adding oil) for five minutes. After roasting, the foods were allowed to cool and powdered in a blender separately.

2. Drying

Dehydration is used for extending shelf life of food products. Drying of vegetables and fruits under controlled conditions of temperature, humidity and air flow has assumed importance in recent years. It provides good texture, colour and flavor and keeping quality (Dhawan, 2008). The selected green leafy vegetable Araikeerai, *(Amaranthus tristis),* was cleaned, washed in water and subjected to drying using the cabinet drier. The temperature adopted for drying was 50º C for 5 – 6 hours. The greens were dried until a residual moisture content of five to six per cent as per the procedure of Kowsalya *et al.,* (2001). For amla, the seeds were removed before drying and cut into small pieces and dried in the cabinet drier at 58±2º C for 5 – 7 hours (Srivasta, 2007). All the ingredients were powdered using an electric grinder to obtain a fine flour with a particle size of 150 to 550 microns.

Preparation of Ladoos

The prepared and processed ingredients powder namely wheat flour, Bengal gram flour, rice flakes, gingelly seeds, flax seeds, greens powder were then measured according to standardized portions and all the mixture were added one by one, blended and mixed well and jaggery syrup of single thread stage consistency was prepared and cooled to lukewarm conditions and added to the above mixture little by little with continuous mixing avoiding the formation of lumps and made into balls, each weighing 25g each, allowed to cool completely and packed in polythene bags.

a) Nutritional evaluation of the developed iron rich formulation

The developed food mixes were analyzed for nutrient contents by AOAC methods. The nutrients analyzed were moisture, ash, fat, fibre, protein, carbohydrate, β - carotene, vitamin C, iron, calcium, phosphorus.

b) Development and standardization of recipes

By using the selected ingredients, three types of recipes were tried out namely ladoo, porridge and steamed cake. Among

these, ladoos prepared were most acceptable and hence using the three variations, ladoos were prepared and were subjected to acceptability trial.

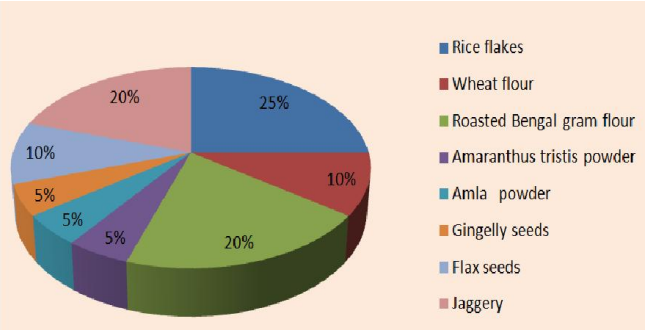

Fig. 1. Composition of Food Supplement

c) Sensory evaluation of the food

Sensory evaluation of a food depends on the criteria's like appearance, flavour, taste, texture, doneness and overall acceptability. It gives an index of the overall acceptability of food. Sensory qualities were assessed by nine point hedonic rating scale for sensory attributes namely colour, flavor, texture, taste, doneness and overall acceptability, by trained panel of 25 semi-trained members of judges. Out of the three formulations, variation I in the form of ladoos was found to be the best one in terms of scoring and shelf life studies and was chosen for supplementation for adolescent during intervention period. Polyethylene pouches were used to pack the developed iron rich food formulations. The storage study was carried out for a period of 90 days. The cost for the prepared supplement was calculated based on market rate.

d) Shelf – life evaluation of the developed iron rich formulation

The shelf-life of the developed iron rich formulation were analyzed by storing them in airtight containers at room temperature for a period of three months.The microorganism most commonly found is bacteria, yeast and mould. Nutrient agar medium was used for bacteria and rose bengal agar medium was used for yeast and mold. Using spread plate method, the total bacterial count, yeast and mould count in the sample were enumerated. The total microbial counts were expressed in colony forming units/grams (Cfu/g). The shelf–life was determined by the serial dilution 1:100 and plated from 10-2 using spread plate technique as stated by (Speck, 1984). The parameters analyzed were moisture content, the peroxide value of the stored sample was determined by extracting fat and titrating iodometrically (Sadhashivam and Manickam, 1992). Free fatty acid (AOCS, 1988), total bacterial count and total mould count were carried out using standard procedure.

RESULTS AND DISCUSSION

Table–I gives the Proximate composition of the developed iron rich formulation from (100g)

1. Nutrient Composition of the Developed Food Products

Table 1 gives the changes in the nutrient content of iron rich food formulation

Table 1. Nutrient content of the iron rich food formulation

Nutrients	Quantity (100g)
Carbohydrates (g)	84.78 ± 0.12
Protein (g)	12.0 ± 0.17
Fat (g)	1.75 ± 0.02
Moisture (%)	1.71± 0.07
Ash (g)	1.81± 0.05
Calcium (mg)	150.25 ± 0.09
Vitamin C (mg)	24 ± 0.78
Beta carotene (µg)	2643±20.1
Iron (mg)	17.3 ± 0.08
Phosphorus (mg)	195.14 ± 0.03

The carbohydrate content of iron rich food formulation was found to be 84.78g. The protein and fat content was found to be 12.0 and 5.75g. The calcium and phosphorus content were found to be 150.25mg and 195.14mg respectively. The iron content was found to be 17.3 mg. The moisture and ash content were noted to be 4.71 per cent and 2.81 respectively. Singh et al. (2009) added that consumption of such value added products may contribute in improving the nutritional status of the population especially the vulnerable section. Rai *et al*., (2008) explained the technologies for various processing treatments such as milling and dry heating reduce the antinutrional factors and increase the digestibility and shelf life of various alternative food products thus enhancing the nutritional value and nutritional security of the undernourished and vulnerable population and food based health management.

The organoleptic evaluation scores of the developed iron rich food formulations for adolescents were assessed using rating scale.

Acceptability scores of the ladoo

The mean sensory scores obtained for the ladoo in sensory evaluation are presented in Table 2.

Table 2. Organoleptic evaluation of ladoos

Organoleptic characteristics	Variation I Scores	Variation II Scores	Variation III Scores	F value
Appearance	4.44±0.64	4.36± 0.48	4.28±0.64	
Colour	4.32±0.68	4.04±0.66	3.92±0.68	
Flavour	4.48±0.50	4.08±0.69	3.96±0.50	0.024*
Texture	4.68±00.47	4.16± 0.61	4.12±0.47	
Taste	4.68±0.47	4.16± 0.37	4.04±0.47	

* Significant at 5% level

The sensory quality parameters such as appearance, texture, taste, flavor and overall acceptability of the developed products were evaluated using rating scale by trained panel of judges. Sensory evaluation of the developed product revealed that the varaiation I of the formulated product gained the maximum score than the other two formulations. Out of the three formulations, variation I scored the best mean score of 4.52 out of 5.0 and variation II scored a mean score of 4.16, whereas variation III scored a mean score of 4.06 out of 5. The various attributes of the organeoleptic characteristics were compared and it was found to be statistically non significant.

The scores of the three variations were compared and the differences were found to be significant at five per cent in variation I.

The overall acceptability scores are given in Table 3

Table 3. Overall acceptability scores of iron rich food formulation

Formulation	Overall acceptability	F value
Variation I	22.60 ± 0.08	
Variation II	20.32 ± 0.10	5.732*
Variation III	20.80 ±0.10	

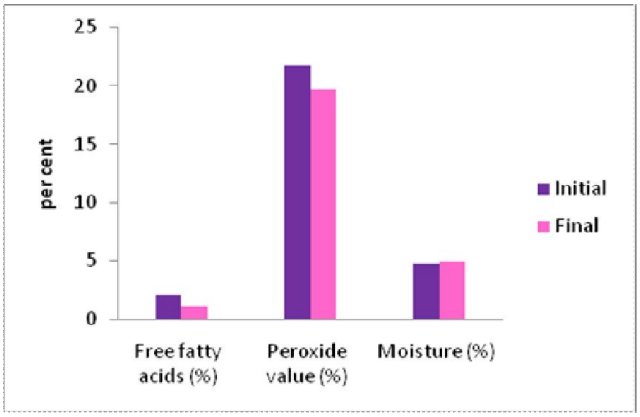

Fig. 2. Shelf Life Studies of the Iron Rich Food Formulation

Table 5. Changes in the microbial content of iron rich food formulation

Microbial content (cfu/g)	Initial	Final
Bacteria	BDL	BDL
Yeast	BDL	BDL
Mold	BDL	BDL

The overall acceptability scores of iron rich food formulation reveals that variation I ranked the highest with the mean score of 22.6 ± 0.08 when compared with variation II and III with the mean scores of 20.32 ± 0.1 and 20.80 ±0.10 respectively. Variation I showed five per cent significant difference between variation II and III. There was no significant difference between variation II and III. Hence variation I was found to be highly acceptable when compared with other two formulations and found to be suitable for supplementation to children. A closer observation on the distribution of responses provided by panel members indicated that the products were well accepted and suitable to be supplemented to the adolescents.

3. Shelf life study of the developed products

During the initial period of storage, the free fatty acid and peroxide values was 2.0 per cent and 21.8 per cent respectively. After three months of storage, the free fatty acid content was reduced to 1.09 per cent and the peroxide value showed a reduction to 19.72 per cent. In a study conducted by Das *et al* (2008), curry leaf powder treated sample showed a significant reduction in fatty acid content from the initial value 0.71 to 0.31 during the storage period which is similar to the results of the present study (Fig. 2). The microbial analysis with reference to the presence of bacteria, yeast and mold showed that the microbial content showed negligible growth and the colony count was found to be in below detectable range. Storage of the formulation of the developed product of the adolescent subject and women for a period of 90 days did not result in any detectable microbial growth and the count was found to be in below detectable range. This proved the microbial safety of the developed food formulation. According to Kowsalya and Indira (2010), in the nutritious mix incorporated extruder products, the microbial load was found to be within the safe limit prescribed after two months of storage.

4. Summary and Conclusion

The consumption pattern of green leafy vegetables among rural adolescent girls was studied, the dehydration protocol of green leafy vegetables was standardized to develop value added products from green leafy vegetables for iron security. The cost of preparation of 50 g ladoo was ₹ 7.50). The low cost supplement will contribute to meet the daily iron requirement of the adolescents. Kitchen garden activity and adequate intake of micronutrients are recommended as long term strategy. Increasing knowledge and awareness through participatory approach and social actions proved to be the best strategy for combating anemia. Involving women in the participatory action research was the key factor for enhancing iron security for the community. It may be concluded that the prepared supplement made from locally available foods rich in micronutrient can be an effective strategy for improving the iron nutriture.

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