

Development and Nutritional Evaluation of Plant Based Iron Rich Food Products

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ABSTRACT

The Anemia is an indicator of both poor nutrition and poor health. The most dramatic health effects of anemia, i.e., increased risk of maternal and child mortality due to severe anemia, have been well documented. In addition, the negative consequences of Iron Deficiency Anemia (IDA) on cognitive and physical development of children, and on physical performance particularly work productivity in adults – are of major concern. In order to prevent and combat IDA and in turn enhancing work productivity of the nation, food based approach has played a significant role with less or no side effects. Four food ingredients namely garden cress seeds, black sesame seeds, lotus stem and cauliflower were procured and utilized for preparation of iron rich food products. These developed food products were evaluated for their organoleptic & nutritional potential. Cheela was found the most acceptable and Idli the least acceptable food product among all four food products developed. Nutritional evaluation depicted that version B of Cheela was found to have maximum amount of iron content among all developed food products.

Keywords: Iron Deficiency Anemia, Iron Rich Food Products, Garden cress seeds, Black sesame seeds, Lotus stem, Cauliflower.

1. Introduction

Micronutrient deficiencies exist in both developing as well as developed countries and may be considered as “HIDDEN HUNGER”. In developing countries they exist in the context of food insecurity, where meeting all energy needs and diversity continues to be the major challenge. Deficiencies in micronutrients such as iron, iodine, vitamin A, folate and zinc can have devastating consequences. Consequently, efforts to reduce micronutrient malnutrition need to be placed in the context that an estimated 854 million people are hungry, 20 million children under the age of 5 suffer from severe malnutrition, and around 1 million children die due to malnutrition each year [1].

Among micronutrients deficiencies, iron deficiency is the most frequent nutritional disorder and one of the leading factors for disability and mortality worldwide and approximately 50% of anemia cases in developing countries are associated with iron deficiency. As well as affecting a large number of children and women in developing countries, it is the only nutrient deficiency which is also significantly prevalent in Industrialized Countries [2]. It contributes significantly to reduced work productivity and economic output as well as to increased morbidity and mortality [3]. Iron deficiency anemia leads to abnormalities in host defence and neurological dysfunction [4, 5]. Increased risks of premature labor [6, 7] and low birth weight [8] have also been reported in association with anemia in pregnancy. Iron is an essential element required for the growth and survival [9]. It has several vital functions in the body. It serves as a carrier of oxygen to the tissues from the lungs by red blood cell hemoglobin, as a carrier of electrons within cells, and as an integrated part of important enzymes systems in various tissues. Iron is reversibly stored within the liver as ferritin and hemosiderin and is transported between different compartments in the body by the protein transferrin. Hemoglobin (Hb), mean cell volume (MCV), transferrin saturation (TSAT), serum ferritin (SF), transferrin receptor (TfR), total iron binding capacity (TIBC), and erythrocyte protoporphyrin (EP) are measurements commonly used when investigating iron status. However, the sensitivity and specificity of these indicators is unclear and a combination of these indicators is sometime used [10].

Iron deficiency is mainly caused by lack of iron in the diet. In the lack of iron the synthesis of iron containing protein Hb becomes compromised. Finally, when Hb concentration falls below a specified cut off values with iron deficiency progress to iron deficiency anemia. Therefore, iron deficiency is called as contributory factor in case of anemia even when the primary cause is another factor [11]. Cut-offs may vary but WHO defines children under 5 years of age and pregnant women living at sea level as anemic if their hemoglobin concentration is <11 g/dL, non-pregnant women as anemic if Hb <12 g/dL, and men as anemic if Hb <13 g/dL. Mild-moderate anemia is Hb 7-10.9 g/dL, and severe anemia is Hb <7

g/dL. The main benefit of using cut-offs is to allow comparisons to be made between population groups. Iron deficiency anemia is not normally symptomatic until hemoglobin level is about 8 g/dL or lowers [12].

A Food-based strategy has the goal of improving nutrition through increasing the availability and consumption of a nutritionally adequate micronutrient rich diet made up of a variety of available foods. Food iron is classified as either Haem iron (the iron from meat, poultry and fish), or non-Haem iron (from cereals, pulses, legumes, fruits and vegetables). In humans, Haem iron is well absorbed and its absorption varies little with the composition of the meal. Absorption is inversely related to the quantity of iron stores in the body, i.e. absorption ranges from 15 to 25 percent in normal subjects and 25 to 35 percent in iron-deficient subjects [13]. The absorption of non-Haem iron ranges from 2 to 20 percent. The specific rate of absorption of non-haem iron from plant foods is highly dependent on the effects of concomitantly ingested dietary components (reducing substances such as ascorbic acid keep iron in the reduced ferrous form) and the amount of body iron stores.

Lepidium sativum L. (Family Cruciferae), popularly known as garden cress in English and chandrashoor in local language in India is a native plant of South West Asia which spread many centuries ago to Western Europe (Xenophon 400 BC). It was used by the ancient Egyptians as a food source and became well known in various parts of Europe, including Britain, France, Italy, Germany, India, Syria and Greece [14] in due course, where it is still used as a minor crop. Persian used to eat this plant even before bread was known. Now, it is being cultivated throughout India and the parts of Asia region. In India, it is mainly cultivated in U.P., Rajasthan, Gujarat, Maharashtra, and Madhya Pradesh [15]. Seeds are recommended for the dispersion of chronic enlargement of spleen. Powder of garden cress seeds with sugar can also be used to cure diarrhea, indigestion and dysentery [16]. A tea spoon full of garden cress seeds boiled in 6 ounces of water for ½ hour and the decoction with a table spoonful of honey is given as an effective medicine to increase breast milk, sexual stamina, and sexual retentivity [17].

Ogle et al. (2001) reported the use of lotus stem (consists of 6, 2.4, 0.2 mg/100 g calcium, iron and zinc respectively) as a vegetable used in salads at Vietnam. For years it has been touted as having many benefits for lungs and respiratory disorders [18]. But it is also helpful in many ailments. Stopping diarrhea, relieving constipation, improving appetite, stops bleeding, dissolves mucus, treats cold with fevers, along with sinus congestion. Treats anorexia heals many spleen and pancreas diseases. There are many more benefits to this amazing fruit [19].

It's free from fat and cholesterol. But also high in fibre, vitamin C, vitamin B6, thiamine, riboflavin, phosphorus, copper, manganese a little calcium and protein.

Cauliflower is a vegetable that belongs to the Cabbage family, which is also the Brassicaceae family or Cruciferae. Its scientific name is *Brassica oleracea* var. botrytis [20]. It is an excellent source of vitamin C and a good source of fibre. It is also a source of vitamin K, folate and potassium and low in fat and cholesterol. It also contains phytochemicals which help in prevention of certain types of cancer [21]. Sulforaphane in cauliflower and other cruciferous vegetables has been found to significantly improve blood pressure and kidney function [22].

Sesame, (*Sesamum indicum* L.), a member of Pedaliaceae family, is an annual shrub with white bell-shaped flowers with a hint of blue, red or yellow with or without branches [23]. Carbohydrates in sesame seed are composed of 3.2% glucose, 2.6% fructose and 0.2% sucrose while the remaining quantity is dietary fibers. Sesame is rich in sulfur containing amino acids and limited in lysine and contains significant amounts of oxalic (2.5%) and phytic (5%) acids [24]. Sesame seed consumption appears to increase plasma gamma-tocopherol and enhanced vitamin E activity which are believed to prevent cancer and heart disease [25]. They have desirable physiological effects including antioxidant activity, blood pressure and serum lipid lowering potential as proven in experimental animals and humans [26].

So the present study was undertaken for the purpose of iron rich plant based food products.

2. Material And Methods

A. Preparation of samples

The selected ingredients of the study are Lotus stem, Niger seeds, Garden cress, Cauliflower. The following are the methods of preparation of above ingredients:

Lotus stem: Fresh sample of Lotus stem was purchased from local market of Moradabad. It was washed thoroughly with tap water followed with sterilized distilled water for the removal of dust and sand particles. The sample was peeled and cut into many small pieces followed by sun drying. It was ground in a stain steel mixer and stored in a plastic air tight container.

Black Sesame seeds: Sample was purchased from local market of Moradabad. It was washed thoroughly with tap water followed with sterilized distilled water for the removal of dust and sand particles. It was sun dried and ground in a stain steel mixer and stored in a plastic air tight container.

Garden cress seeds: Garden cress seeds were collected from the Chakrapani Ayurveda Clinic, Jaipur. The seeds were cleaned and rendered free from dust. Dust free seeds were powdered in the grinder. Then stored in the plastic air tight container for chemical analyses.

Cauliflower: Fresh good quality cauliflower was procured from the local market of Moradabad. It was washed thoroughly with tap water followed with sterilized distilled water for the removal of dust and sand particles. Later, the Head (white curd) of cauliflower was cut into pieces and kept for sun drying. Dried pieces of head were powdered in the grinder. Lastly, the powder was collected in the plastic air tight container.

B. Product Development

Products were developed using composite flours of black sesame seeds, garden cress seeds, lotus stem and cauliflower as main ingredients. Shifting from hundred of ideas was imperative in order to design a new or improvise, tempting and nutritious products. Hence, this step was the first step for the investigation. Using information from key informants, various books and internet, an exhaustive list of possible products was drawn.

Selection of Products

In order to select the products, various books were consulted. The products were selected with the motive to make it suitable in every respect for acceptability Major points considered for selection of recipes were:

- Low cost of ingredients
- Easily available ingredients
- Healthy
- Easy to prepare
- Appealing for all age groups
- Less preparation time

Standardization and Development of products

Standardization of products was done by following a thoughtful process. Standards were developed without using the flours of garden cress, black sesame seeds, cauliflower, lotus stem and their versions were developed by using different percentage of these flours at 2 & 3 %.

Acceptability Evaluation

Any food product should be accepted by consumers and provide them satisfaction. Acceptance depends on the characteristics of a product like appearance, color, taste, texture, after taste, and overall acceptability. When the quality of a food product is assessed by means of human sensory organs the evaluation is said to be sensory or subjective or organoleptic. Every time food is eaten, a judgment is made. Sensory quality is a combination of different senses of perception coming into play in choosing and eating food. Appearance which can be judged by the eye, e.g. color, size, shape, uniformity, and absence of defects is of first importance in food selection [27].

Sensory Evaluation

Sensory evaluation is considered to be an important analytical tool in the present day competitive environment to judge the acceptability of food among the potential consumers [28].

A panel is an analytical tool in sensory evaluation the value of foods depends on the objectivity precision and responsibility of the judgment of the panelists before a panel can be used with confidence. The availability of panelists, motivation general attitude and emotional state of the panelist may be responsible for the reliable and valid judgment.

Marine et al. (1965) has suggested that the person who serves as a panelist should be in good health and should absent themselves when suffering from conditions that might interfere with normal function to taste and smell [29]. The price of information was passed into the panelists.

The motivation of the panelists affects his response to a great extent. Therefore, the panelists were made to feel that they were doing an important activity and that their contribution was very important. The panelists were given an explanation about the sensory attribute they were supposed to measure [30].

So test subject should meet the following conditions:-

- **Sensitivity:** panel member should have normal of olfactory and gustatory sensitivity, which can be improved by training.
- **Age:** all interested persons regardless of their age were admitted.
- **Avoidance of disturbance during test:** sensory analysis requires intense concentration by the panel members therefore, disturbance such as noise, off odors etc, must be avoided. In addition, test subjects should not have the chance to influence each other by facial expression or orally conveyed results.
- **Additional points to be taken into consideration:** the panel membrane should rinse their mouth properly before starting the test.

Method for the selection of panel member

Selection of panel members involved the screening of 30 postgraduate students. All of those were subjected to triangle difference test and 15 students having sharp discrimination, discretion and communication powers were selected and then preceded for other evaluation.

Triangle Test

This test was named so because it involved the presentation of three samples to the panel members in a triangular form but in practice they are kept in a straight line. In the present study, triangle difference test was conducted using lemon water. Among the three samples two were same and one was different. The panel members were asked to pick out in each triangle set the sample, which was different.

Nine Point Hedonic Method

Hedonic rating relates to pleasure or displeasure experience. It was evaluated by selected semi trained panel member after giving detailed instruction regarding the method of scoring and the significance of their judgment.

Procedure

- This was conducted in separate room free of noise and odor and having proper lighting.
- Each sample was introduced separately to each of the panel member.
- The member asked to give scores according to their preference on the Performa on the bases of all attributes of hedonic scale (9 point)
- Water was provided after testing each sample to remove any other taste.
- No communication between panelists was allowed.
- Judges suffering from cold and ill health were not allowed to evaluate.

C. Statistical analysis

Statistics is concerned with scientific methods for collecting, organizing, summarizing, presenting and analyzing data as well as withdrawing valid conclusions and making reasonable decisions on the basis of such analysis. Average and standard deviation was applied.

D. Nutritional composition of products

For the nutritional evaluation of all products, their nutritive value was calculated according to raw ingredients used.

3. Results & Discussion

A. Organoleptic Evaluation

Mean scores of all versions of developed products for all attributes of organoleptic evaluation are appended in the table 1. Among the three versions of mathri, in all attributes of organoleptic evaluation, standard stood out and it was followed by version 1 and 2 respectively. In Ladoo, appearance wise standard and version 1 got equal scores and followed by version 2. Standard got first place and followed by version 1 and 2 respectively in remaining attributes. In other products; Idli & Cheela same trend was followed. Panel members preferred standard most and version 1 and 2 was their second and third choice. Version 1 and 2 were less accepted as compared to standard in all attributes but they were also in the range of "Liked slightly to very much" (Table 1). In a study done by Chauhan & Inteli (2015), taste and flavor of samples supplemented with 2 gm and 5 gm dried cauliflower green leaf powder were rated as neither liked nor disliked and very much disliked with these values i.e. 4.80 and 2.80, respectively [31].

Average of overall acceptability of all three versions of each product was taken and depicted through Fig.1. Cheela was found the most acceptable among all four food products. It was followed by Ladoo and Mathri. Idli was the least acceptable product.

Nutritional Evaluation

Among three version of Mathri, energy, protein, fat, crude fibre and iron content of version B was found the most as compared to that of other versions; standard and version A. While carbohydrate content was found maximum in standard among three versions of Mathri. In ladoo, fat fibre and iron content was found maximum in version B. Energy content was found maximum in version A and standard was rich in protein and carbohydrate content. In Idli, standard was having the maximum content of energy and carbohydrate while protein, fat, fibre and iron content was found maximum in version 2. Protein and carbohydrate were found maximum in standard which was developed without incorporation of composite flours of garden cress seeds, black sesame seeds, lotus stem and cauliflower. On the other hand, version B was having the maximum amount of energy, fat, iron and fibre as compared to that of standard and version 1 of developed food products by incorporation of composite flours of garden cress seeds, black sesame seeds, lotus stem and cauliflower (Table 2). Garden cress possesses anti haemagglutinating, hypoglycaemic, antihypertensive, fracture healing properties and significant bronchodilatory activities [32]. Studies have also demonstrated the protective effect of garden cress against carcinogenic compounds. The seeds also possess significant anti-inflammatory, antipyretic, analgesic and coagulant

activities [33]. Seeds are recommended for the dispersion of the chronic enlargement of spleen. In Sikkim and West Bengal, the plant is used by the aboriginals in the treatment of asthma, bronchitis, dysentery, pain, pneumonia, and stomachache [34]. A recent survey of different regions of Saudi Arabia showed that the seeds are commonly used as febrifuge, antirheumatic, and diuretic and are also used in menstrual and abdominal discomfort. They are also used to enhance sexual desire [35]. Sesame seed consumption appears to increase plasma gamma-tocopherol and enhanced vitamin E activity which are believed to prevent cancer and heart disease [25]. Sesame seed contains lecithin which has antioxidant and hepatoprotective activity [36]. Lecithin is also likely effective for reducing hepatic steatosis in long term parenteral nutrition patients and a successful treatment for dermatitis and dry skin [37]. Sesame oil is a pharmaceutical aid used as a solvent for intramuscular injections and has nutritive, demulcent, and emollient properties [38] and has been used as a laxative [39]. Sesame oil is known to reduce cholesterol due to the high polyunsaturated fat content in the oil. Other uses include the treatment of blurred vision, dizziness, and headaches. The Indians have used sesame oil as an antibacterial mouthwash, to relieve anxiety and insomnia [40]. A recent clinical trial proved that sesame oil was significantly more effective for treating nasal mucosa dryness due to a dry winter climate than isotonic sodium chloride solution [41]. In addition, sesame oil contains large amounts of linoleate in triglyceride form which selectively inhibited malignant [42].

Food Products	Version	Appearance	Color	Taste	Texture	Flavor	After taste	Over all acceptability
Mathri	Standard	8.53±0.51	7.73±1.03	8.53±0.63	8.20±0.67	8.73±0.45	8.53±0.51	8.46±0.51
	Version 1	7.93±0.59	7.26±0.96	7.93±0.70	8.00±0.79	7.60±0.63	7.40±0.51	7.40±0.45
	Version 2	7.46±0.63	7.00±1.00	7.33±0.89	7.20±0.067	7.40±0.98	6.80±1.12	7.70±0.50
Ladoo	Standard	8.40±0.63	8.40±0.74	7.86±0.83	8.46±0.63	8.00±0.84	8.46±0.74	8.33±0.81
	Version 1	8.40±0.73	8.20±0.45	7.60±0.89	7.60±0.63	7.80±0.94	7.66±0.72	7.66±0.72
	Version 2	7.80±1.08	7.90±0.79	7.40±0.82	7.30±1.04	7.70±0.79	7.20±0.67	7.20±0.70
Idli	Standard	8.20±0.67	8.20±0.77	8.30±0.72	8.20±0.77	8.60±0.48	8.50±0.63	8.40±0.51
	Version 1	7.20±0.86	7.73±0.70	7.40±0.74	6.93±0.79	8.00±0.75	7.40±0.82	7.40±0.51
	Version 2	6.80±0.74	7.33±0.72	6.90±0.88	6.60±0.81	7.20±0.67	6.80±0.86	7.00±0.37
Cheela	Standard	8.40±0.74	7.80±0.91	8.20±0.56	8.50±0.51	8.00±0.88	8.30±0.48	8.60±0.50
	Version 1	7.80±0.77	7.60±0.61	8.00±0.70	8.40±0.63	7.70±0.70	7.40±0.44	7.80±0.35
	Version 2	7.60±0.82	7.50±0.63	7.80±0.83	8.00±0.84	7.40±0.83	7.30±0.72	7.60±0.50

Table 1: Organoleptic evaluation of food products developed by incorporation of composite flours of garden cress seeds, black sesame seeds, lotus stem and cauliflower:

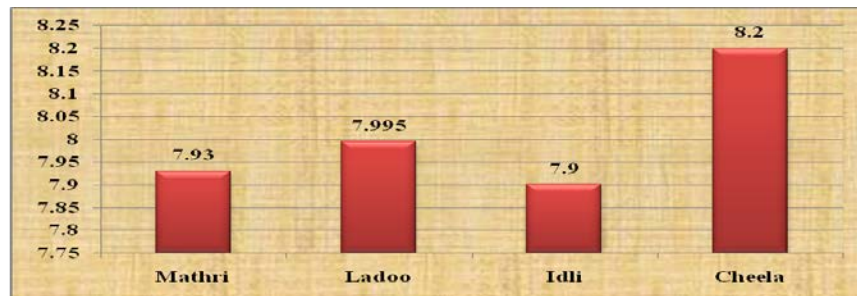


Fig. 1: Average of overall acceptability scores of all three versions of developed products

Cauliflower contains several phytochemicals, common in the cabbage family, which may be beneficial to human health. A high intake of cauliflower has been associated with reduced risk of aggressive prostate cancer. A high intake of cauliflower has been associated with reduced risk of aggressive prostate cancer [43]. World Cancer Research Fund in USA [44] concluded that a diet rich in crucifers is likely to protect humans against colon, rectum, and thyroid cancers, and when consumed with vegetables rich in other phytonutrients, can protect against cancer in other organs. Crucifers rich in glucosinolates including broccoli, cabbage, Brussels sprouts, and kale have been shown to protect against lung, prostate cancer, breast cancer, and chemically induced cancers [45-49].

Lotus stem is highly effective in lung diseases and respiratory diseases, it contains dietary fiber, calcium, phosphorus, iron, vitamin C and a lot of other minerals that help maintain our health while also prevent dangerous diseases like Cancer, Inflammation, Asthma and Digestive disorders. It keeps our bowel movements regulated, keeps our respiratory system healthy, strengthens our heart, has dietary fiber and enhances our hemoglobin [50].

Among all four products, energy content was found maximum in version A of *Ladoo*, protein in standard of *Cheela*, fat in version B of *Ladoo* and carbohydrate in standard of *Mathri*. While crude fibre and iron content were found maximum in version B of *Cheela*. Iron is an essential element for almost all living organisms as it participates in a wide variety of metabolic processes, including oxygen transport, deoxyribonucleic acid (DNA) synthesis, and electron transport. However, as iron can form free radicals, its concentration in body tissues must be tightly regulated because in excessive amounts, it can lead to tissue damage [51].

Table 2: Nutritive Evaluation of developed food products by incorporation of composite flours of garden cress seeds, black sesame seeds, lotus stem and cauliflower per 100 g

Products	Energy (Kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Crude Fibre (g)	Iron (mg)
Mathri						
Standard	403.2	9.9	10.81	66.51	0.27	2.43
Version A	406.23	10.4	12.06	64.24	1.15	7.4
Version B	408.72	10.66	12.68	63.11	1.59	9.89
Ladoo						
Standard	363.23	9.69	11.36	65.46	1.52	3.93
Version A	462.11	7.47	22.19	58.13	1.882	7.69
Version B	440.13	7.57	22.77	56.45	2.26	10.07
Idli						

Standard	290.48	8.94	1.44	60.44	0.16	1.32
Version A	287.74	9.26	2.68	56.62	1.042	6.51
Version B	286.73	9.44	3.3	54.72	1.48	8.83
Cheela						
Standard	340.58	21.98	6.66	48.19	1.28	7.15
Version A	426.11	21.33	17.55	45.71	2.102	11.53
Version B	427.69	21.47	18.1	45.64	2.53	13.91

4. Conclusion

The developed food products are good source of protein and iron and also with in the range of acceptability. In a nut shell, these products are having potential to prevent and combat IDA in all age groups and enhance the productivity of the nation as IDA is hampering the physical, mental and social development of individuals and ultimately the work capacity and productivity of the nation.

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