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RESEARCH ARTICLE

DEVELOPMENT AND EVALUATION OF FUNCTIONAL FOOD MIXES AS A DIETARY APPROACH TO NON COMMUNICABLE DISEASES

***Usharani, R. and Lakshmi, U. K.**

Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore-43

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ABSTRACT

Over the last few years consumers' interest in health and functional foods has increased considerably in industrialized countries thus offering an opportunity for agro-food sector to add value to agricultural commodities. Functional food is any fresh or processed food claimed to have a health-promoting or disease-preventing property beyond the basic function of supply of nutrients. Functional foods offer potential health benefits that could enhance the well-being of consumers and reduce the economic and social costs of treating non-communicable diseases. Today the world appears to be increasingly interested in the health benefits of foods and have begun to look beyond their basic nutritional benefits to disease prevention and health enhancement. Traditional systems of medicine owe their significance to the bioactive components that have their origin in plant sources and most of them were associated with routine food habits. Functional foods include amla, carrot, oats, fatty fish, soy, tomatoes, nuts, grape juice, greens, milk, almond, walnuts, blue berries etc. Functional foods arose as nutritional science evolved from indentifying and correcting nutritional deficiencies. It promotes optimum health and reduces the risk of chronic diseases. Foods like bengal gram dhal, black gram, carrot, tomato, cauliflower leaves, amla, flax seed and soya were selected for the formulation of health mixes for supplementation. Pepper, cumin seeds, red chillies and salt were added to improve the taste and acceptability of food mixes. The present research was planned to formulae and prepare health mixes based on functional foods, study the acceptability, nutrient content, shelf life and cost to know their economic viability.

INTRODUCTION

Over the last few years consumers' interest in health and functional foods has increased considerably in industrialized countries thus offering an opportunity for agro-food sector to add value to agricultural commodities. Functional food is any fresh or processed food claimed to have a health-promoting or disease-preventing property beyond the basic function of supply of nutrients. Functional foods offer potential health benefits that could enhance the well-being of consumers and reduce the economic and social costs of treating non-communicable diseases (Devliadas *et al,* 2010). Today the world appears to be increasingly interested in the health benefits of foods and have begun to look beyond their basic nutritional benefits to disease prevention and health enhancement. According to Ullah and Khan, (2008) traditional systems of medicine owe their significance to the bioactive components that have their origin in plant sources and most of them were associated with routine food habits. Functional foods have potential benefits on health and scientific evidence is supporting the role of functional foods in prevention and treatment of several diseases. Cancer, diabetes, heart disease and hypertension are the most important diseases that can be treated or prevented by functional foods and other diseases include osteoporosis and arthritis (Sahelian, 2011). Philip (2010) reported that foods of natural source provide considerable protection against many of the leading chronic diseases that take the lives of millions of people worldwide each year. Processed foods packed with sugar, refined carbohydrates and hydrogenated fats lead to a continual state of inflammation throughout the body. Metabolic syndrome, diabetes, hypertension, heart disease and Alzheimer's disease are all fueled by the release of dangerous chemical messengers that are the result of inflammation. Small changes in diet over a short period of time have been shown to significantly lower the risk of disease and improve the quality of life. Healthy natural food combinations reduce the risk of chronic diseases. Functional foods include amla, carrot, oats, fatty fish, soy, tomatoes, nuts, grape juice, greens, milk, almond, walnuts, blue berries etc. Functional foods arose as nutritional science evolved from indentifying and correcting nutritional deficiencies. It promotes optimum health and reduces the risk of chronic diseases (www.ific.org)

****Corresponding author: Usharani, R.***
Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore-43

Food supplementation is one of the effective ways of improving the health status of adults by means of increasing the serum calcium level, regulating the blood glucose and blood pressure. Keeping all these points in mind the investigator selected low cost, locally available ingredients and foods familiar to the community to formulate food supplements to manage diseases like diabetes, hypertension and musculoskeletal disorders.

India is experiencing a rapid health transition by carrying an increasing burden of non communicable diseases with more than 30 million people with chronic heart disease and 118 million people with high blood pressure. This figure is expected to go up to 214 million people with blood pressure by the year 2025 if preventive measure are not taken (Goenka *et al.,* 2009). High dietary intake of fruits, vegetables and whole grains is strongly associated with reduced risk of developing chronic diseases, such as cancer and cardiovascular diseases (CVD), which are the highest causes of death in Europe, United States and in most of the industrialized countries (EFSA, 2008). It is estimated that one-third of all cancer deaths in industrialised countries could be avoided through appropriate dietary formulations. This suggests that dietary behavioral changes, such as increasing consumption of fruits, vegetables, and whole grains, and related changes in lifestyle, are practical strategies for significant reduction of the incidence of cancer (Terry *et al.,* 2001). Considering all the health benefits of functional food ingredients bengal gram, black gram, tomato, cauliflower leaves, carrot, amla, flax seeds, soya, cumin seeds, pepper and coriander seeds were selected for the development of health mixes. The present study was carried out with the following objectives

- Formulation and preparation of health mixes based on functional foods
- Evaluation of the acceptability, nutrient content and anti nutritional factors of health mixes
- Determination of the shelf life and cost of health mixes

MATERIALS AND METHODS

Selection of Functional foods for the development of Health mixes

Bengal gram (channa) dhal is a very important pulse crop that grows as a seed of a plant Cicer Crietinu in the leguminosae family. Channa dhal is good for diabetics because it has low glycemic index which regulates the blood glucose level. Dilawari *et al,* (2001) reported that Bengal gram dhal was found to be more effective in reducing post prandial plasma glucose levels. Black gram belongs to the leguminosae family. Whole black gram is a rich source of protein, fiber, several vitamins and essential minerals such as calcium and iron. Black gram consist of polyphenols and carotenoids which are effective in the prevention of cardiovascular disease, cancer and diabetes (Scalbert, 2005). Carrots contain predominant phytochemicals such as anthocyanins, phenolic acids and carotenoids. These phytochemicals could be useful in the treatment of metabolic syndrome since anthocyanins improve glucose tolerance, hypertension and insulin resistance (Poudyal *et al.,* 2010). Tomatoes commonly used in the diet, are a major source of antioxidants and contribute to the daily intake of a significant amount of these molecules. Tomato products are excellent sources of potassium, folate, Vitamin A, C, E and fiber. It contains a variety of phytochemicals including lycopene, α-carotene and β-carotene (USDA, 2004). Cauliflower leaves are rich in folate, vitamin C, vitamin E and beta carotene and contain some important nutrients like indole-3-carbinol and phytonutrient sulforaphane. It contains folate which helps in making and stimulating the blood and prevents symptoms of anaemia. Cauliflower leaves can be incorporated in common recipes for increasing bioavailability of the minerals. Cauliflower leaves are a good source of minerals such as calcium, copper, iron, manganese and potassium. Manganese is used as co-factor for the antioxidant enzyme superoxide dismutase in the body. Potassium is an important intracellular electrolyte which helps to counter the hypertensive effects of sodium (Bhuvaneswari and Ramya, 2014). Amla is considered as a versatile and powerful antioxidant that protects the body against all types of cancer and helps to reduce blood pressure (Srikumar, *et al,* 2005). Amla plays an important role in brain and supports the heart and mental function, regulates elimination, strengthens the lungs, enhances fertility, helps urinary system, promotes healthier hair, increases vitality, flushes out toxins, strengthens the eyes, improves muscle tone, acts as antioxidant and enhances immunity. (www.healthing.about.com/od/herbaltheraphy/a/amlaberry_x.htm).

Flax seed also known as linseed (linumusitatissimum) is a member of the genus linumin, the family linaceae. It is a food and crop that is grown in cooler regions of the world (www.en.wikipedia.org/wiki/flax). Flax seed is used for many conditions related to the gastrointestinal tract, including constipation, colon damage due to over use of laxatives, diarrhoea, inflammation of the lining of the large intestine (diverticulitis), irritable colon or irritable bowel syndrome (IBS), sores in the lining of the large intestine (ulcerative colitis), inflammation in the lining of the stomach (gastritis) and inflammation of the small intestine (enteritis). Flaxseed is also used for disorders including high cholesterol, coronary artery disease, heart and blood vessels, hardening of the arteries (atherosclerosis), and high blood pressure (hypertension). (www.webmd.com...lingredientmono-991-flaxseed.astr). Consumption of flax seed has also been shown to reduce total and LDL cholesterol (Bierenbacum *et al.,* 1993).

Stephen Daniells (2012) observed that consumption of milled flax seed incorporated buns (30g/day) for one year by peripheral arterial disease subjects with hypertension led to a greater reduction in systolic blood pressure of about 15 mmHg. Sirtori (2001) reported that soy isoflavones reduced the plasma cholesterol levels and osteoporosis. The role of soya bean is in the prevention of disease especially in relation to heart disease, osteoporosis and cancer. Isoflavones promote bone growth and retard bone loss. It was observed that isoflavones of soy protein when substituted for animal protein, enhanced the bone strength (Messina, 2000). Cumin is a good source of manganese, iron, vitamins and minerals. The antioxidant content of cumin seeds is more effective (Kalaivani *et al,* 2013). Cumin seeds are effective in increasing insulin sensitivity, thereby control diabetes. It has anti-asthma properties as it is a bronchodilator and cures asthma (www.wellness.com/5607/herb-profile-cumin). Black pepper

is the king of spices. It has anti microbial properties, anti-cancer, anti bacterial and anti-inflammatory. It is also rich in vitamin C which prevents hypertension. Pepper controls blood cholesterol and suppresses bad cholesterol thereby decreasing the risk of cardiovascular disease (www.king-of-spices-10-black-pepper-health-benefits). Black pepper is a natural antibiotic and contains fiber, potassium, iron, vitamin C and vitamin K which controls stomach ailments, anaemia and heart disease (Mcgee, 2004). Coriandrum sativum (coriander) has been reported to have a number of possible medicinal attributes including antispasmodic, carminative and stomachic properties (Dhanapakiam *et al.,* 2008). Additionally, coriander has been advocated as an anti-diabetic remedy. Considering the beneficial effects of functional foods bengal gram dhal, black gram dhal, carrot, tomato, cauliflower leaves, amla, flax seeds, soya, pepper, coriander seeds, pepper and cumin seeds were selected for the study.

Formulation and Preparation of Health Mixes based on Functional Foods

For the formulation of Basic health mix, bengal gram dhal, black gram dhal, cumin seeds, pepper, coriander seeds and chilli powder were procured from departmental stores. Carrot, tomato, cauliflower leaves and amla were purchased from the local vegetable market. Flax seed and soya flour for the preparation of variations were ordered in advance and obtained from departmental stores located at Coimbatore. Bengal gram dhal and black gram dhal were roasted and powdered separately. Carrots and tomatoes were chopped and amla was deseeded and chopped into fine pieces. Cauliflower leaves were cleaned free from foreign matters and thick stems. All the vegetables were sun dried on a clean plastic sheet till the moisture content significantly reduced to safe levels. Then the ingredients were milled using a pulveriser to obtain the respective powders. All the spices were roasted and powdered using a pulveriser. Various proportions of ingredients were tried out and acceptability tests were done to find out the best proportion. For the Basic health mix 30g bengal gram dhal flour, 15g black gram dhal flour and 5g each of all the spices and 5g each of all the vegetable powders were blended homogenously to obtain 80g of mix which had a good acceptability. Based on the health problems among adult men, functional foods like amla powder for diabetes mellitus, flax seeds powder for hypertension and soya flour for musculoskeletal disorders respectively were added to Basic health mix. Fifteen g each of amla powder or Flax seeds powder or soya flour were added to 80g of Basic health mix to get variation 1, 2 and 3 respectively. Variation 1 can be given as a supplement to adults with diabetes mellitus, variation 2 for hypertension and variation 3 for musculoskeletal disorder. Figure 1 shows the steps involved in the preparation of the heath mixes.

Acceptability Testing and Nutrient Analysis of Health Mixes

Acceptability testing through sensory evaluation was done for the Basic health mix and 3 variations. A panel of 25 semi-trained members were requested to evaluate different proportions of the Basic health mix and the variations organoleptically using a five point scale. The best proportions of the selected health mixes according to the panel members, revealed that all the mixes scored more than 19 out of 25 highlighting the good acceptability of health mixes. The Basic health mix and the three variations were analysed for their

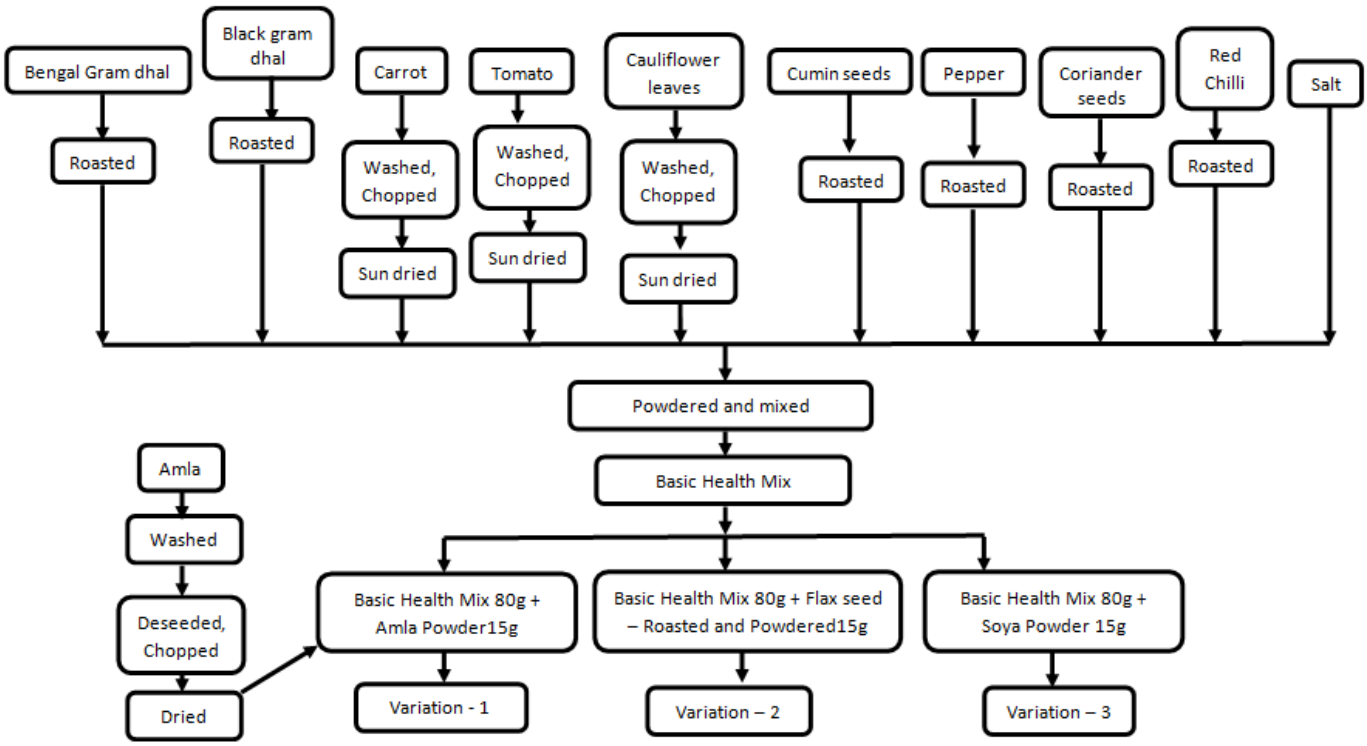

Figure 1. Steps in the preparation of functional food mixes

nutrient content. The proximate principles like energy and carbohydrate were analysed using NIN (2004) procedures and protein, fat, moisture, crude fiber, dietary fiber and ash were analysed using the AOAC (2000) procedures. Minerals like calcium, phosphorus, sodium, potassium, iron, magnesium and vitamins such as vitamin A, C and E were analysed using the ISI (2004) procedures.

Anti nutritional factors of Health Mixes

Anti nutritional factors in foods may inhibit the utilization of nutrients in our body. Hence the important anti nutritional factors like oxalate, phytate, tannin and alkaloid were estimated for all the health mixes. The modified methods of the Ukpabi and Ejidoh (1989) were used for the determination of oxalate content of the samples. The phytate of each of the samples was determined through phytic acid determination using the procedure described by Lucas and Markaka (1975). Estimation of tannin was done by adopting the method of Sujata Wangkheirakpam *et al.* (2012). The alkaloid content was determined gravimetrically (Haborne, 1973).

Shelf life of Health Mixes

All the food mixes were examined initially and after a storage period of three months for the microbial content (bacteria, yeast and mould) to evaluate the shelf life of the health mixes. Microbial content was found out by standard plate count, yeast and mould count and the results were compared with the permissible limits.

Computation of Cost of Health Mixes

The total cost incurred in the preparation of the health mixes based on the market prices prevalent during the specific time, was computed. The cost of unit weight of food mixes was calculated and the economic feasibility was assessed.

RESULTS AND DISCUSSION

Acceptability testing of the developed functional food mixes

Table I presents the mean scores given by the taste panel members to the various functional food mixes with the best proportions formulated for the study.

Table 1. Mean Accepatbility Scores Obtained by the Developed Functional Food Mixes

(Max Score=25)

Quality	Maximum Score	Basic Health mix	Variation 1 (Amla)	Variation 2 (Flax seed)	Variation 3 (Soya)
Colour	5	4.0	3.5	4.5	4.7
Appearance	5	4.0	4.1	4.2	4.3
Flavour	5	3.8	4.1	4.3	4.8
Texture	5	3.9	3.9	4.2	4.0
Taste	5	4.2	4.2	4.1	4.3
Total Score	25	19.9	19.8	21.3	22.1

For color, variation 3 obtained the maximum score of 4.7 followed by variation 2, with 4.5 score. Basic health mix got a score of 4 whereas amla powder incorporated mix got only 3.5 score for color since it was slightly brownish in colour. With regard to appearance, variation 3 and 2 got a maximum score of 4.3 and 4.2 respectively. Basic health mix obtained a high score of 4 for appearance followed by 4.1 for variation 1. For flavor, variation 3, containing soya obtained a highest score of 4.8 followed by 4.3 for variation 2. Amla incorporated variation 1 and Basic health mix got somewhat a lower score of 4.1 and 3.8 respectively for flavour. All the mixes scored nearly similar scores for texture ranging from 3.9 to 4.2 since all the powders were ground uniformly. For taste, variation 3 with soya got a slightly highest score of 4.3 whereas Basic health mix and variation 1 got 4.2 and variation 2 got 4.1. For taste, all the health mixes were evaluated equally good. The overall scores revealed that soya incorporated variation 3 got the maximum score of 22.1 followed by variation 2 with flax seed with a score of 21.3. Both Basic health mix and variation 1 got 19.9 and 19.8 respectively. None of the mixes were found to be organoleptically unacceptable.

Nutrient analysis of the functional food mixes

Table II depicts the analysed values of proximate principles present in the formulated functional food mixes

Table 2. Proximate Principles of the Developed Functional Food Mixes

(In 100g)

Proximate Principles	Basic Health Mix	Variation– 1 (Amla)	Variation- 2 (Flax seed)	Variation- 3 (Soya)
Energy (Kcal)	384	333	368	384
Carbohydrate (g)	69.10	59.81	47.42	52.06
Protein (g)	12.80	15.75	18.60	18.37
Fat (g)	3.00	3.41	11.52	8.05
Moisture (g)	3.07	3.43	1.63	4.32
Ash (g)	8.00	9.44	12.20	10.40
Crude fibre (g)	6.00	8.16	8.60	6.80
Dietary fibre (g)	8.00	8.30	8.40	8.80

Among the food mixes developed, Basic health mix and variation 3 provided 384 Kcal of energy per 100g each followed by variation 1 and variation 2 which provided 333 and 368 Kcal of energy respectively. The total carbohydrate content of basic health mix and variation 1 was 69.10 and 59.81g per 100g respectively, while variation 3 and variation 2 contained 52.06 and 47.42g of carbohydrate per 100g respectively. The energy value of all the health mixes ranged from 333 to 384 kcal per 100g and carbohydrate content ranged from 47.4g to 69.1g per 100g proving their good supplementary value. Protein content of health mixes ranged from 12.8 to 18.6g per 100g with a maximum content in variation 2 and 3 with 18.6 and 18.37g per 100g respectively might be due to the incorporation of flax seed and soya in these mixes. With regard to total fat content, variation 2 possessed the maximum of 11.52g per 100g due to the incorporation of flax seed in this mix followed by variation 3 with soya which had 8.05g of fat per 100g. Basic health mix and variation 1 contained 3.0 and 3.41g of fat per 100g respectively.

Among the food mixes variation 3 had a maximum moisture content of 4.32g per 100g followed by variation 1 and basic health mix which had 3.43 and 3.07g whereas variation 2 had a minimum moisture content of 1.63g per 100g respectively. These levels are found to be minimum and safe for good storage. Ash content of all the mixes ranged from 8.0g per 100g in Basic health mix to a maximum of 12.2 g per 100g in variation 2 which had flax seed. Dietary fiber content of variation 3 was the maximum with 8.8g per 100g followed by variation 2, variation 1 and basic health mix which had 8.4, 8.3 and 8g per 100g respectively. All the mixes had a similar range of dietary fiber 8 to 8.8g per 100g. In the case of variation 1 and 2 the crude fiber content was high with 8.16 and 8.4g per cent respectively, whereas Basic health mix and variation 3 had 6.0 and 6.8g per 100g of crude fiber respectively. The mineral content of the developed functional food mixes is presented in Table III.

Table 3. Mineral Content of the Developed Functional Food Mixes

(In 100g)

Minerals	Basic Health Mix	Variation– 1 (Amla)	Variation- 2 (Flax seed)	Variation- 3 (Soya)
Calcium (mg)	180	419	527	472
Potassium (mg)	12.1	13.0	13.2	12.0
Sodium (mg)	6.0	7.2	5.3	5.6
Iron (mg)	2.0	3.9	4.4	4.4
Magnesium (mg)	110	163	206	135
Phosphorus (mg)	68.0	72.0	80.0	88.1

Among the minerals, variation 2 contained a higher amount of calcium 527mg per 100g followed by variation 3 and variation 1 with 472 and 419mg in 100g respectively. Basic health mix had only180mg of calcium per 100g. With regard to potassium content, variation 2 had 13.2mg per 100g slightly higher than other mixes which had 12 to 13 mg per 100g. Sodium content of variation 1 was found to be the maximum with 7.2mg per 100g. Other variations and Basic health mix had 5.3 to 6.0mg per 100g of sodium. Variation 2 and 3 had a higher amount of 4.4mg per 100g of iron whereas Basic health mix had only 2.0 mg followed by variation 1 which had 3.9mg per 100g. Magnesium content was found to be more in variation 2 with 206mg followed by variation 1 and 2 which had 163 and 135 mg per cent respectively. Basic health mix had less magnesium of 110 mg per cent only. With regard to phosphorus, the content was more in variation 3 with 88.1mg per cent followed by variation 1 and 2 with 72 and 80mg respectively. Basic health mix had only 68mg percent of phosphorus. In general, all the functional food variations had more mineral content

Table 4. Vitamin Content of the Developed Functional Food Mixes

(In 100g)

Vitamins	Basic Health Mix	Variation– 1 (Amla)	Variation- 2 (Flax seed)	Variation- 3 (Soya)
Total carotenoids (µg)	1020	1420	1280	1320
β- carotene (µg)	420	460	368	360
Vitamin – C (mg)	17.28	23.85	8.78	10.94
Vitamin – E (µg)	0.20	0.28	0.44	0.30

than the Basic health mix which might be due to the incorporation of specific functional foods in variations. Table IV presents the vitamin content of the developed functional food mixes. Total carotenoids content of functional food mixes ranged from 1020 to 1420µg per 100g with a maximum content in variation 1 with amla based mix. Beta carotene content also ranged from 360 to 460 µg per 100g with a maximum in variation 1 with 460 µg whereas variation 2 and 3 had 368 and 360 µg per cent respectively. Vitamin C content ranged from 8.78 to 23.85mg per 100g with a maximum content in variation 1 with amla based mix. Vitamin E content of the mixes ranged from 0.20 to 0.44 µg per 100g with variation 2 a flax seed incorporated mix had a maximum of 0.44 µg per 100g. The anti nutritional factors of the developed functional food mixes is given in table V

Table 5. Anti Nutritional Factors of the Developed Functional Food Mixes

(In 100g)

S.No	Functional food Mixes	Basic Health Mix	Variation -1	Variation -2	Variation - 3
1.	Oxalate (mg)	146.08	407.02	122.68	82.41
2.	Phytate (g)	0.51	0.53	0.51	0.46
3.	Tannin (µg)	53	256	72	51
4.	Alkaloids (g)	73.90	85.01	71.15	79.74

Among the four samples, variation-1 had the highest oxalate content of 407.02mg per 100g followed by Basic health mix which had 146.08mg per100g. All variation 3 and variation 2 had very low amounts of oxalate in them ranging from 82.41mg to 146.08mg in 100g respectively. Reports have shown that the lethal dose of oxalate is between 200 and 500mg/100g (Pearson, 1976). Noonan and Savage (1999) noted that the intake of 4 to 5 g of oxalate is the minimum dose that can result in death in an adult human. The amounts of oxalate reported in the present study are safe and within permissible levels. With regard to phytate content except variation 3 with 0.46mg per cent all other mixes had a range of 0.51 to 0.53mg per cent. Large amounts of phytic acids have been reported to be present in fiber-rich foods. Such food, however, are pharmacologically recommended because they protect human from cardiovascular diseases and some forms of cancer (Norhaizan and Nor-Faizadatul, 2009). Inspite of this advantage, phytic acid reduce bioavailability of minerals because it has strong binding affinity to them. This chelation process increases the incidence of mineral deficiency diseases because the minerals are made unavailable for absorption by the intestine (Ekholm *et al.,* 2003). In general the anti nutritional factors in Health mixes were found to be within safe levels.

In the case of tannins, variation 1 contained a maximum of 256µg and variation 3 had a minimum of 51µg per 100g. The tannin content of all the other mixes ranged between 53 to 72 µg per 100g. Aletor and Adeogun (1995) reported that high level of tannins (76 to 90g kg Diabetes Mellitus) could be lethal if consumed. Sheep that consumed 0.9g hydrolysable tannins per kg of body weight showed signs of toxicity in 15 days (Kumar, 1991). In the case of alkaloids, variation 1 had

85.01 per cent being the highest whereas other variations had 71.15 to 79.74mg per 100g.

Shelf life of the Health mixes

The results of the microbiological testing of the health mixes after a storage for 3 months is presented in Table VI

carbohydrate content of Basic health mix and variation 1 was 69.10 and 59.81g per 100g respectively, while variation 3 and variation 2 contained 52.06 and 47.42g of carbohydrate per 100g respectively. The energy value of all the health mixes ranged from 333 to 384 kcal per 100g and carbohydrate content ranged from 47.4g to 69.1g per 100g proving their good supplementary value. Protein content of mixes ranged

Table 6. Microbiological Testing of the Selected Health Mixes

Criteria	Basic Health mix		Variation -1 (Amla)		Variation – 2 (Flax seed)		Variation -3 (Soya)	
	Initial	After 3 months	Initial	After 3 months	Initial	After 3 months	Initial	After 3 months
Total Bacterial count (cfu/g)	Abs	3×10^3	Abs	4×10^3	Abs	4×10^3	Abs	4×10^3
Yeast count	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Mould count	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

BDL – Below Detectable Limits Abs-Absent

Table 7. Cost of the Health Mixes

Category	Basic Health mix (Rs)	Variation-1 (Amla) (Rs)	Variation-2 (Flax seed) (Rs)	Variation-3 (Soya) (Rs)
Raw materials	14.70	20.50	16.42	15.97
Processing charges	0.50	0.50	0.50	0.50
Packaging charges	0.30	0.30	0.30	0.30
Cost per 100g	15.50	21.30	17.22	16.77

BDL – Below Detectable Limits Abs-Absent

The Prevention of Food Adulteration Act (PFA, 1954) recommends a total bacterial count not more than 40,000 per g and absence of yeast and mould count in 0.1g of the sample in cereal based food products. The total bacterial count of the health mixes was nil initially and ranged between 3×10^3 and 4×10^3 per g at the end of three months storage period which was within safe limits. The yeast and mould counts were found to be below detectable limits in all the four food mixes both initially and after a three months storage period. This indicates that the health mixes were free from spoilage and safe for consumption upto three months after preparation.

Cost of the Health mixes

Cost is an important criteria to be considered for any supplementation. The cost incurred in the preparation of health mixes (for 100g) is given in Table VII. The total cost in the preparation of the health mixes was Rs.15.50 per 100g for Basic health mix, being the minimum followed by Rs.21.30 per 100g for variation 1, Rs.17.22 per 100g for variation 2 and Rs.16.77 per 100g for variation 3. The cost of 100g of health mixes ranged from Rs.15.50 to Rs. 21.30. It is evident that the health mixes are far more economical, affordable and can be easily prepared at home compared to commercial health mixes.

Conclusion

This research was aimed at formulation and preparation of health mixes based on functional foods which were analysed for nutrients, anti nutritional factors and studied for shelf life. Bengal gram dhal, black gram dhal, carrot, tomato, cauliflower leaves, amla, flax seed and soya were used in the development of functional food mixes. Among the food mixes developed, Basic health mix and Variation 3 provided 384 Kcal of energy per 100g each followed by Variation 1 and variation 2 which provided 333 and 368 Kcal of energy respectively. The total

from 12.8 to 18.6g per 100g with a maximum content in variation 2 and 3 with 18.6 and 18.37g per 100g might be due to the incorporation of flax seed and soya in these mixes. With regard to total fat content, variation 2 possessed the maximum of 11.52g per 100g due to the incorporation of flax seed in this mix followed by variation 3 with soya which had 8.05g of fat per 100g. Among the minerals, variation 2 contained higher amount of calcium 527mg per 100g followed by variation 3 and variation 1 with 472 and 419mg in 100g respectively Basic health Mix had only180mg per 100g. With regard to potassium content, variation 2 had 13.2mg per 100g slightly higher than other mixes which had 12 to 13 mg per 100g. Total carotenoids content of functional food mixes ranged from 1020 to 1420µg per 100g with a maximum content in variation 1 with amla based mix. Beta carotene content also ranged from 360 to 460 µg per 100g with a maximum in variation 1 with 460 µg whereas variation 2 and 3 had 368 and 360 µg per cent respectively. Vitamin C content ranged from 8.78 to 23.85mg per 100g with a maximum content in variation 1 with amla based mix. Vitamin E content of the mixes ranged from 0.20 to 0.44 µg per 100g with variation 2 a flax seed incorporated mix had a maximum of 0.44 µg per 100g.

Among the four samples, variation 1 had the highest oxalate content of 407.02mg per 100g followed by Basic health mix which had 146.08mg per100g. All Variation 3 and variation 2 had very low amounts of oxalate in them ranging from 82.41mg to 146.08mg in 100g respectively. The levels of oxalate reported in the present study safe and within permissible levels. With regard to phytate content except variation 3 with 0.46mg per cent all other mixes had a range of 0.51 to 0.53mg per cent. In the case of tannins, variation 1 contained a maximum of 256 µg and variation 3 had a minimum of 51µg per 100g. The tannin content of all the other mixes ranged between 53 to 72 µg per 100g. In the case of alkaloids, variation 1 had 85.01 per cent, whereas other variations had 71.15 to 79.74mg per 100g. The total bacterial count of the health mixes was nil initially and ranged between

3×10^3 and 4×10^3 per g at the end of three months storage period which were within safe limits. The yeast and mould counts were found to be below detectable limits in all the four food mixes both initially and after a three months storage period. This indicates that the health mixes were free from spoilage and safe for consumption up to three months after preparation. The total cost in the preparation of the health mixes was Rs.15.50 per 100g for Basic health mix, being the minimum followed by Rs.21.30 per 100g for variation 1, Rs.17.22 per 100g for variation 2 and Rs.16.77 per 100g for variation 3. The cost of 100g of health mixes ranged from Rs.15.50 to Rs. 21.30. It is evident that the health mixes are far more economical, affordable and can be easily prepared at home compared to commercial health mixes. From the study it might be concluded that the developed health mixes can be supplemented to adults with diabetes mellitus, hypertension and musculoskeletal disorder.

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