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Formulation and Quality Evaluation of Iron Rich *Namakpare* Mixes Using Finger Millet

Pragya Singh[1*] and Sarita Srivastava[2]

[1]*Assistant Professor (Applied Human Nutrition), School of Human Nutrition, Food Science and Technology, Hawassa University, Awassa, Ethiopia*

[2]*Professor, G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India- 263 145*

***Corresponding author: Pragya Singh**

ABSTRACT

Iron deficiency anemia is a major public health problem affecting numerable people throughout the globe. Finger millet is amongst the major crop of Uttarakhand and is rich in calcium and iron. So the present study was undertaken with the objective to develop convenience mixes rich in iron for *namakpare* using finger millet along with either locally grown food items like soybean flour, mint leaf powder and refined wheat flour or fortifying with suitable chemical (Fe_2SO_3). The mixes were studied for nutritive value viz. proximate composition, *in-vitro* protein digestibility, calcium, iron, phosphorus, *in-vitro* iron bioavailability and antinutrients. The storage stability of mixes was evaluated by sensory evaluation, bacterial and fungal counts. The *namakpare*s were studied for proximate composition, sensory quality and acceptability. The results led to the conclusion that finger millet upto 60 % can be incorporated to formulate iron rich *namakpare* mix. These *namakpare* mixes were nutritious (crude protein 9.34-23.68 %, crude fat 0.85-4.57 %, crude fibre 0.30-3.51 %, total ash 0.60-4.51 %, carbohydrates 54.90-59.79 %, physiological energy 355-370 Kcal/100 g, *in-vitro* protein digestibility 62.34-78.26 %, ionizable iron 878.00-1342.00 μg %, *in-vitro* iron bioavailability 28.67-42.00 %, calcium 22.00-517.37 mg %, phosphorous 119.00-434.90 mg %) low cost, acceptable at laboratory and field level. These mixes also had good storage stability. These mixes can be used successfully in supplementary feeding programmes.

Key words: Finger millet, soybean, mint leaves, Ferrous Sulphate, proximate composition, sensory quality

INTRODUCTION

Nutritional well being is a sustainable force for health and development and maximization of human potential. The nutritional status of a community has been recognized as an important indicator of national development. In other words, malnutrition is an impediment in national development and hence assumes the status of national problem. Iron deficiency anemia is one of the common nutritional problems affecting millions of people in both developing and developed countries. There is substantial evidence that anemia in children is associated with decreased physical and mental development, impaired immune function and reduced capacity of leucocytes to kill microorganisms. Anaemia is a major nutritional problem, affecting 20-70 % of the population in various countries (Biradar *et al.*,2012; Rammohan *et al.*,2012; WHO, 2008).

Finger millet *(Eleusine coracana)* is amongst the major crop of Uttaranchal agriculture. Finger millet grain is highly nutritious, being richer in protein, fat and minerals especially calcium and iron than rice and wheat. The present study was undertaken with the objective to develop iron rich *namakpare* mixes using finger millet, to assess the nutritive value and storage stability of the mixes. Development of *namakpare* using these mixes and to assess the nutritive value and acceptability of the *namakpare* both at laboratory level and field level.

METHODOLOGY

Finger millet variety VL-204 was procured from V.P.K.A.S., Almora (Uttarakhand), soybean PK-1042 was procured from C.R.C., G.B.P.U.A.&T., Pantnagar (Uttaranchal). Refined wheat flour, mint leaves and ferrous sulphate tablets were procured from local market of Pantnagar.

Preparation of raw material for preparing *namakpare* mixes

All the Ingredients were prepared as per method given by Singh and Srivastava (2007).

Iron rich *namakpare* mix (IBM)

Three types of convenience mixes were formulated in this category having varying proportion of finger millet flour (VL-204) ranging from 50 to 70 %. The amount of soybean flour and mint leaf powder was kept constant. The refined wheat flour was used as filler.

Ingredients (g) used for preparation of INM

Ingredients	INM_1	INM_2	INM_3
Finger millet flour (VL-204)	50	60	70
Soybean flour	20	20	20
Mint leaf	10	10	10
Refined wheat flour	20	10	0

On the basis of sensory evaluation of the *namakpare* prepared using the mixes the most acceptable mix was chosen and its iron content was determined. Based on the amount of iron present in the mix, two controls were formulated as shown below:

	Finger millet flour (g)	Refined wheat flour (g)	Fe_2SO_3 (g)
$CINM_1$	60	40	0.1337
$CINM_2$	0	100	0.1449

Standardization and preparation of *namakpare* using above convenience mixes

Ingredients	Amount
Convenience mix	100 g
Fat	40 g
Ajwain	5 g
Salt	To taste
Water	30 ml

METHOD OF PREPARATION

Convenience mix, *ajwain* and salt were mixed thoroughly. Hard dough was prepared adding 20 g fat and required amount of warm water. The prepared dough was then divided into small units. The small units were then rolled out. Using a sharp knife it was cut horizontally and diagonally. These were then deep fried in hot oil in a pan.

Sensory quality of *namakpare*

To find out the most acceptable food product, the food products for sensory quality were evaluated using 'nine point hedonic scale' (1 to 9). The sensory quality attributes viz. colour, flavour, texture, appearance and overall acceptability were studied by score card method (Amerine *et al.*, 1965). The products, which scored highest was selected for determination of nutrient composition.

Determination of nutrient composition of convenience mixes

Proximate principles i.e moisture, crude protein, crude fat, crude fibre, total ash (AOAC, 2000), carbohydrates by difference, physiological energy was calculated, calcium (AOAC, 1975), phosphorous (Fiske and Subba Row as given in Ranganna, 1986), iron (Wong's method as given by Ranganna, 1986), tannins (Price *et al.*, 1978) and phytates (Haug and Lantzsch, 1983), *In vitro* protein digestibility (Akeson and Stahman, 1964) and *In vitro* iron bioavailability (Rao and Prabhavati, 1978) were determined in selected mixes. All the estimations were done in triplicate and reported on dry weight basis.

Acceptability of food products

All the food products with good sensory quality were evaluated for acceptability at field level. A total of 50 subjects consisting of adult males, females and children were included in sensory panel in field trials. These subjects belonged to the hill community of Uttaranchal. All of them lived at Pantnagar (Jha colony and *Chakphere* colony) and were selected purposively. Subjects were asked to taste the food products and rank it on nine-point Hedonic scale.

Nutritive value of food products

Proximate composition of food products was done as per methods given above. All the estimates were done in triplicate.

Evaluation of storage stability of the mixes

Storage stability of biscuit mixes was evaluated by studying the fungal count (APHA, 1976) and total bacterial count (APHA, 1976) of the mixes. A 300 g of dry mix was stored in duplicate, in pearl pet plastic jars (air tight containers) of 500 g capacity at room temperature (20°C-35.6°C) for a period of three months. The samples were drawn at one month interval and studied.

Sensory evaluation after storage

The biscuit were prepared using stored convenience mixes and evaluated for sensory quality by nine point Hedonic scale as mentioned above. The scores obtained for *namakpare* which were prepared from fresh convenience mixes and stored convenience mixes were compared.

RESULTS AND DISCUSSION

Iron rich *namakpare* mixes were formulated using finger millet along with either mixing with locally grown foodstuffs or fortifying it with Fe2SO3. Similarly control mix was also formulated by fortifying refined wheat flour with Fe2SO3.On the basis of the results obtained by using nine point Hedonic scale it was observed that INM_2, INM_1 and INM_3 were liked moderately (7.81), liked moderately (7.54) and liked slightly (6.81) respectively. There exists a statistically significant difference between the mean scores (Table I). INM_1 would be denoted as selected iron rich *namakpare* mix (SINM).

Table I: Rating of iron rich *namakpare* mixes (INM) using nine point Hedonic scale

Mix	Scores	Preference	F value	*S/NS
INM_1	7.54	Like moderately	6.29	S
INM_2	7.81	Like moderately		
INM_3	6.81	Like slightly		
CD at 5 %	0.594			

Nutritive value of *namakpare* mixes rich in iron

SINM had moisture, crude protein, crude fat, total ash, and crude fibre content of 8.83, 23.68, 4.57, 4.51 and 3.51 %, respectively. Carbohydrate content was 54.9 % and physiological energy content was 355 Kcal / 100 g. Iron, calcium and phosphorus were 23.80, 517.37 and 434.90 mg / 100 g while ionisable iron was 878 µg / 100 g. The value of *in vitro* protein digestibility was 62.34 % of crude protein while *in vitro* iron bioavailability was 28.67 %. Among antinutritional factors tannins and phytates were 136.28 and 88.99 mg / 100 g respectively.

The mix $CINM_1$ had moisture, crude protein, crude fat, total ash, and crude fibre content of 7.60, 9.34, 0.88, 1.20 and 1.19 % respectively. Carbohydrate content was 79.79 % and physiological energy content was 364.44 Kcal / 100 g. Iron, calcium and phosphorus were 23.80, 244.20 and 196.40 mg / 100 g while ionisable iron was 1083 µg / 100 g. The value of *in vitro* protein digestibility was 70.74 % of crude protein while *in vitro* iron bioavailability was 36.50 %. Among antinutritional factors tannins and phytates were 128.64 and 95.79 mg / 100 g respectively.

The mix $CINM_2$ had moisture, crude protein, crude fat, total ash, and crude fibre content of 7.62, 11.0, 0.85, 0.60 and 0.30 % respectively. Carbohydrate content was 79.63 % and physiological energy content was 370 Kcal / 100 g. Iron, calcium and phosphorus were 23.80, 22.0 and 119.00 mg / 100 g while ionisable iron was 1342 µg / 100 g. The value of *in vitro* protein digestibility was 78.26 % of crude protein while *in vitro* iron bioavailability was 42.00 %. Among antinutritional factors tannins and phytates were 32.39 and 35.74 mg / 100 g respectively.

When the nutritive value of SINM, $CINM_1$ and $CINM_2$ was compared it was observed that INM had significantly higher moisture, crude protein, crude fat, total ash, crude fibre, calcium and phosphorous as compared to $CINM_1$ and $CINM_2$. *In vitro* protein digestibility, *in vitro* iron bioavailability and ionisable iron content of $CINM_2$ were significantly higher ($p<0.05$) when compared with SINM and $CINM_1$. The iron content in all the three mixes was *at par* (Table II).

The higher amount crude protein in SINM is contributed by soybean flour, mint leaf powder contributed high amount of total ash, crude fibre, calcium and phosphorus. The $CINM_2$ contained low amount of tannins and phytates. Antony and Chandra (1998, 1999) observed a significant negative correlation of *in vitro* digestibility with phytates, phenols, tannins and antitryptic activity. Raboy (2000) concluded that dietary phytic acid binds not only with the seed derived minerals but also with other endogenous minerals encountered in the digestive tract.

Table II: Nutritive value of iron rich *namakpare* mixes

	SINM	Control ($CINM_1$)	Control ($CINM_2$)	Mean	CD at 5 %
Moisture (%)	$8.83±0.20^b$	$7.60±0.28^a$	$7.62±0.22^a$	8.01	0.46
Crude protein (%)	$23.68±0.15^c$	$9.34±0.25^a$	$11.00±0.16^b$	14.67	0.92
Crude fat (%)	$4.57±0.25^b$	$0.88±0.44^a$	$0.85±0.63^a$	2.10	0.11
Crude fibre (%)	$3.51±1.00^c$	$1.19±0.28^b$	$0.30±0.15^a$	1.66	0.19
Total ash (%)	$4.51±0.36^c$	$1.20±0.42^b$	$0.60±0.20^a$	2.10	0.23
Carbohydrate (%)	$54.90±0.50^a$	$79.79±0.80^b$	$79.63±1.20^b$	71.44	2.13
Physiological energy (Kcal/100g)	$355±1.60^a$	$364±1.30^a$	$370±0.99^a$	363	34.55
In vitro protein digestibility (% crude protein)	$62.34±1.20^a$	$70.74±0.90^b$	$78.26±0.86^c$	70.44	7.37
Iron (mg %)	23.80±0.36	23.80±0.15	23.80±0.20	23.80	__
Ionizable iron (µg %)	$878±0.25^a$	$1083±2.30^b$	$1342±2.10^c$	1101	46.07
In vitro iron bioavailability (%)	$28.67±0.48^a$	$36.50±0.20^b$	$42.00±0.15^c$	35.72	3.45
Calcium (mg %)	$517.37±0.22^c$	$244.20±1.00^b$	$22.00±0.80^a$	261.19	23.03
Phosphorous (mg %)	$434.90±0.75^c$	$196.40±0.45^b$	$119.00±0.25^a$	250.10	23.03
Tannins (mg %)	$136.28±14.86^b$	$128.64±11.20^b$	$32.39±16.59^a$	99.10	11.51
Phytates (mg %)	$88.99±5.20^b$	$95.79±3.43^b$	$35.74±2.09^a$	73.50	9.49

Means followed by different letters in column differ significantly at 5% level of significance.

Sensory evaluation by nine point Hedonic scale:

The mean sensory scores of iron rich *namakpare* have shown in Table III. The results obtained showed that the mean scores of SINM, $CINM_1$, $CINM_2$ were 7.08 (like moderately), 7.50 (like moderately) and 8.25 (like very much), respectively. There exists statistically significant difference ($p<0.05$) between the mean sensory scores of the three products.

The results depicted that all the products were acceptable on nine point Hedonic scale. So these *namakpare* can be successfully used as snack items for community feeding to combat the problems of iron deficiency.

Table III: Rating of iron rich *namakpare* using nine point Hedonic scale

Namakpare	Scores	Preference	F value	*S/S
SINM	7.08	Like moderately	9.77	S
$CINM_1$	7.50	Like moderately		
$CINM_2$	8.25	Like very much		
CD at 5 %	0.544			

Sensory quality of the developed *namakpare* after storage of convenience mixes:

Sensory quality of *namakpare* was accessed after storing convenience mixes for three months. The sensory scores of the food products developed from iron rich convenience mixes have been given in the table IV.

The results showed that all types of iron rich *namakpare* (SINM, $CINM_1$, $CINM_2$) showed a non significant difference ($p>0.05$) in sensory scores when prepared from fresh and stored mixes. Sensory scores of the *namakpare* prepared from fresh SINM was significantly higher ($p<0.05$) as compared to that which is prepared from the stored mix but the score of stored product was above acceptable range (6.00). The above results on sensory quality lead to the conclusion that all the food products were found acceptable after 3 month of storage at room temperature. The products showed the preference rating of like very much or like moderately accept.

Table IV: Sensory scores of the Iron rich *namakpare* after storage of convenience mixes

Food product	Before storage (scores)	3 months (scores)
SINM	7.60*	6.90*
Control ($CINM_1$)	7.60	7.40
Control ($CINM_2$)	8.70	8.40

*Significant difference at $p<0.05$

Total bacterial count and mould count of convenience mixes

Mould count and total bacterial count were assessed to study the storage stability of convenience mixes. Mould count and total bacterial count was assessed at the interval of 1 month for a period of 3 months.

The results revealed that all the convenience mixes initially had very low bacterial count per g mix (Table.V). However the bacterial count increased significantly ($p<0.05$) upon storage for three months. The mixes SINM, $CINM_1$, $CINM_2$ had initial bacterial count of 0.28×10^2, 0.24×10^2 and 0.22×10^2 bacteria per g sample, respectively which increased significantly up to 5.89×10^2, 4.68×10^2 and 4.74×10^2 bacteria per g sample, respectively after 3 months of storage.

The above results showed that storing convenience mixes at room temperature led to an increase in total bacterial count. However the total bacterial count of all the convenience mixes, initially as well as during storage has been found to be quite low as compared to the permissible limit of 10^5 given by Bureau of Indian standards (IS: 7463, 1988).

In all the convenience mixes, namely SINM, $CINM_1$, $CIMN_2$, moulds were not detected initially and also when stored for 3 months at room temperature (Table V).

The above results demonstrated that all the convenience mixes could be stored at room temperature without any significant change in sensory quality. The mixes are stable for at least 3 months at room temperature.

Acceptability of food products prepared using convenience mixes

Iron rich *namakpare* SINM, control $CINM_1$ and $CINM_2$ had mean sensory scores of 7.95 (like moderately), 7.41 (like moderately) and 8.50 (like very much), respectively. The results showed that all the products were acceptable at field level. Sensory scores, on nine point Hedonic scale, obtained at laboratory level were compared with scores obtained in field for each food product. The SINM *namakpare* were liked moderately at laboratory level (7.81 ±0.66) and field level (7.95 ± 0.42). There was a non significant ($p>0.05$) difference between the scores at laboratory and field level. The $CINM_1$ had the sensory scores of 7.50 ± 0.24 (like moderately) at laboratory level and 7.41 ± 0.39 (like moderately) at field level. The difference between the two scores was statistically non significant ($p>.05$). $CINM_2$ showed the preference attribute of liked very much both at laboratory (8.25 ± 0.44) and field level (8.50 ± 0.28). The results lead to the conclusion that all the types of iron rich *namakpare* (SINM, $CINM_1$, $CINM_2$) were acceptable at laboratory and field level (Table VI)

Table V: Microbial load in various Iron rich namakpare mixes

Convenience mixes	Storage period (months)	Total bacterial count per g	Mould count per g	F-value	CD at 5 %
SINM	0	0.28×10^2	ND		
	1	1.96×10^2	ND	1597.70	19.19
	2	2.49×10^2	ND		
	3	5.89×10^2	ND		
Control ($CINM_1$)	0	0.24×10^2	ND	1492.75	4.94
	1	1.20×10^2	ND		
	2	1.88×10^2	ND		
	3	4.68×10^2	ND		
Control ($CINM_2$)	0	0.22×10^2	ND	1760.19	4.62
	1	1.27×10^2	ND		
	2	1.68×10^2	ND		
	3	4.74×10^2	ND		

ND-Not detected

Table VI: Comparison of laboratory and fields sensory scores of Iron rich *namakpare*

Food product	Laboratory level (scores)	Field level (scores)
SINM	7.81 ± 0.66	7.95 ± 0.42
Control ($CINM_1$)	7.50 ± 0.24	7.41 ± 0.39
Control ($CINM_2$)	8.25 ± 0.44	8.50 ± 0.28

*Significant difference at $p < 0.05$

Nutritive value of iron rich *namakpare*

On analyzing nutritive value, it was observed that SINM, $CINM_1$ and $CINM_2$ *namakpare* had moisture content of 5.00, 5.25 and 5.40 %, respectively. Crude protein content of SINM, $CINM_1$ and $CINM_2$ was 19.73, 7.78 and 9.16 %, respectively. The crude fat content was highest for SINM (15.47 %) followed by $CINM_1$ (12.40 %) and $CINM_2$ (12.37 %). The crude fibre content of SINM, $CINM_1$ and $CINM_2$ *namakpare* was 2.29, 0.99 and 0.30 %, respectively. Total ash content of SINM, $CINM_1$ and $CINM_2$ *namakpare* was 3.75, 1.00 and 0.50 %, respectively while total carbohydrates were 53.13, 72.58 and 72.27 %, respectively. Energy content of SINM *namakpare* was 431 Kcal / 100 g while of $CINM_1$ it was 433 Kcal / 100 g and for CINM2 *namakpare* it was 437 Kcal / 100g. The SINM, $CINM_1$ and $CINM_2$ *namakpare* had calcium content of 431.14, 203.50 and 15.70 mg / 100 g while phosphorus content was 362.41, 163.66 and 99.16 mg / 100 g, respectively. All the three types of *namakpare* had similar iron content of 19.83 % (Table.7). On comparing the three mixes, it was observed that SINM had significantly higher ($p<0.05$) percentage of crude protein, crude fat, crude fibre, total ash, calcium and phosphorus. The above results demonstrated that *namakpare* are good source of protein, fat, energy, ash, calcium and iron. *Namakpare* served as a nutritious snack item.

Higher amount crude protein in SINM is contributed by soybean flour, mint leaf powder contributed high amount of total ash, crude fibre, calcium and phosphorus. The $CINM_2$ contained low amount of tannins and phytates. Antony and Chandra (1998, 1999) observed a significant negative correlation of *in vitro* digestibility with phytates, phenols, tannins and antitryptic activity. Raboy (2000) concluded that dietary phytic acid binds not only with the seed derived minerals but also with other endogenous minerals encountered in the digestive tract.

Table VII: Nutrient composition of iron rich *namakpare*

	SINM	Control (CINM$_1$)	Control (CINM$_2$)	Mean	CD at 5%
Moisture (%)	5.00±0.23^a	5.25±0.33^a	5.40±0.20^b	5.21	0.25
Crude protein (%)	19.73±0.36^c	7.78±0.25^a	9.16±0.42^b	12.22	0.80
Crude fat (%)	15.47±1.20^b	12.40±1.36^a	12.37±1.50^a	13.40	0.73
Crude fibre (%)	2.92±0.30^c	0.99±0.20^b	0.30±0.65^a	1.40	0.32
Total ash (%)	3.75±0.60^c	1.00±0.20^b	0.50±0.15^a	1.75	0.57
Carbohydrates (%)	53.13±2.50^a	72.58±1.30^b	72.27±1.60^b	65.99	4.15
Physiological energy value (kcal /100 g)	431±2.50^a	433±2.52^a	437±2.80^a	434	12.00
Calcium (mg /100 g)	431.14±0.16^c	203.50±0.24^b	15.70±060^a	216.78	13.58
Iron (mg /100 g)	19.83±0.10	19.83±0.13	19.83±0.33	19.83	__
Phosphorus (mg / 100 g)	362.41±0.23^c	163.66±0.32^b	99.16±0.14^a	208.41	11.57

Means followed by different letters in columns differ significantly at 5% level of significance.

CONCLUSION

The study leads to the conclusion that finger millet upto 60% can be successfully incorporated to formulate iron rich *namakpar* mixes. These mixes are low cost, nutritious, had good storage stability and were acceptable at both laboratory and field level. These mixes can be successfully used for supplementary feeding programmes.

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