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Research Article

Efficacy of Region-Specific Dietary Intervention on the Nutritional Status of Undernourished Farm Women

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Abstract

Keeping in view the poor diet quality of rural Indian women especially those belonging to low socio-economic status, in the present study an attempt was made to develop a Ready to Use (RTU) nutrient dense mixture from the indigenous and cost-effective ingredients like cereals, pulses, oilseeds etc. Out of various combinations, the one with a composition of Wheat flour: 50g, Chickpea flour: 25g, Green gram flour: 20g, Flaxseeds: 5g was selected and tested for the preparation of different food products which are consumed by rural Punjabi families commonly with the best organoleptic characteristics. Further, sixty farm women belonging to low socio-economic status were selected and were divided into two groups- Intervention (I) and Delayed intervention (DI) with 30 subjects in each group. Intervention group was provided with the mixture in their daily diets along with fortnight nutrition education for a period of four months, while no intervention was provided to delayed intervention group. Post-intervention, improved nutrient intake (in terms of increased energy, protein, fat, calcium and iron) was observed which resulted in a significant increase in weights (3.89 kg), body mass index (1.48 kg/m^2) and heamoglobin (0.54 mg/dl) levels of the intervention group subjects. So, it can be concluded that the dietary supplementation along with the nutrition education can be an effective strategy to enhance the nutritional status of the women-a vulnerable section of the society.

Keywords: Farm Women; Nutrient Dense Mixture; Ready to Use; Undernutrition

Introduction

In the developing/under developed countries, the health and nutritional status of women is of great concern because of the changing roles of the women. A great regional and national variation in the gap between level of under nutrition among men and women has been reported [1]. More than 1 billion women globally are experiencing at least one form of malnutrition [2]. In some societies there is a disparity regarding food distribution between men and women, as men are considered the bread earners of the family and perceived to have heavier workloads. However, with a change in the composition and structure of the families, the gender specific roles are also under-going rapid change. Even the rural women have no escapism from that. The workload of the household chores and agricultural tasks which women are deeply involved in most rural communities in the underdeveloped countries have made them bearing load even higher than the men. Hence, they require additional energy and nutrients. Therefore, there is a need to ensure that women are physically and nutritionally stable to conveniently carry out all the household responsibilities facing them [3].

A recent report has documented that about 1.9 billion adults are overweight or obese, while 462 million are underweight world-

wide [4]. In India, health has improved significantly in the recent decades, but progress has been uneven and inequitable. Maternal and child under-nutrition disproportionately burdens the poor, and the scheduled tribes and castes [5,6], especially those residing in rural areas [7]. About 18.7 percent of women of reproductive age in India are undernourished with a body mass index (BMI) less than 18.5 kg/m^2 [8]. Poverty amplifies the risk of and risks from malnutrition. Moreover, the high cost of healthy diets coupled with persistent high levels of income inequality put healthy diets out of reach for around 3 billion poor people in every region of the world [4].

The diets of women in India are often too poor to meet their nutritional needs. Hence, it becomes absolutely necessary to develop cost effective and nutrient dense food products which are culturally sensitive and at the same time convenient to use. Along with that women also need to be educated about the adaptation of meagre changes in daily diets for the improvement in their nutritional and health status. Most of the previous work reported on the supplementation studies has been done with regard to improvement in the nutritional status of the children. Hence, the present research was designed to develop a Ready to Use (RTU) nutrient dense mix particularly for adult women, which could be used for the easy preparation of the commonly consumed energy and protein dense food items in rural areas of Punjab. This approach is expected to help rural women in improving their health and nutritional status.

Material and Methods

Formulation of nutrient dense mixture

For the formulation of the mixture, indigenous and cost-effective ingredients such as wheat, chickpea flour, green gram flour and flaxseeds were selected and procured from local market of Ludhiana city in a single lot in the required quantities. Various combinations of the selected ingredients were tried and tested for the preparation of different products namely *Mithi roti, Gugule and Panjiri* which are culturally relevant to the rural Punjabi population. The composition of RTU mixture and method of preparation of products is given in table 1. These products were purposively selected because they are prepared with addition of fat and sugar, which makes them energy dense. Traditionally, wheat flour alone is used for the preparation of these products, however, in the present investigation the certain proportion of wheat flour was replaced with the pulses and oilseeds to make the rich in protein and other micronutrients. The organoleptic evaluation of the developed products was carried out in a well-lit food laboratory of the department of Food and Nutrition by a panel of 15 semi-trained judges using a nine-point hedonic rating scale [9]. The best acceptable mixture (Wheat flour: 50g, Chickpea flour: 25g, Green gram flour: 20g, Flaxseeds: 5g) was selected for the purpose of dietary intervention. The formulated mixture was stored in airtight containers at ambient temperature for further nutrient analysis and preparation of different food products.

Composition of the RTU nutrient Dense Mixture	
Wheat flour, g	50
Chickpea flour, g	25
Green Gram flour, g	20
Flax seeds (Roasted and powdered), g	5
Method of preparation	
Mithi Roti	
Dissolve 50 g of jaggery in about 50 ml of water and add to 100 g of RTU mix along with 10 g of fat to make a smooth dough. The amount of water can be adjusted according to the requirement. Take a medium sized ball from the dough and roll it into chapati with a rolling pin, roast it on a pre-heated *tava* till the *roti* gets cooked evenly. Apply fat (~ 10 g) on top.	
Panjiri	
Roast 100 g of RTU mix in about 20 g of fat on a medium flame till golden brown. Add *shakkar* in the mixture. Add nuts in it as per your convenience.	
Gulgule	
Dissolve 50 g of jaggery in about 50 ml of water and add to 100 g of RTU mix along with 10 g of fat to make a smooth batter. The amount of water can be adjusted according to the requirement. Make small balls of the batter and deep fry in pre heated oil till golden brown.	

Table1: Composition of the RTU nutrient Dense Mixture and method of preparation of the products.

Nutritional evaluation of mixture and developed products.

All the samples of prepared food products were dried in hot air oven at 60 ± 2°C, ground to form powder and stored in airtight pouches for further nutritional analysis. Standard Association of Official Analytical Chemists protocol was used for proximate composition analysis of the formulated mixture as well as the developed products [10]. Minerals namely iron, zinc and calcium were estimated using atomic absorption spectrophotometer (AAS, Varian model) [11].

Selection of subjects

Purposive sampling method was used for the selection of sixty farm women having Body Mass Index (BMI) less than 18.5 kg/m^2 in the age group of 30-50 years from three villages namely Duburji, Beggowal and Harnampura (located at a distance of approximately 15-20 Km from Ludhiana city) of Doraha block, Ludhiana district of Punjab. Base on their socio-economic profile, the selected subjects were divided into two matched groups i.e. Intervention (I) and Delayed Intervention group (DI) consisting of 30 subjects in each group.

Data collection

For the dietary intervention, prior permission from Institutional ethical committee was obtained vide letter No. DR/2018 13632-44 dated 12.07.18. Afterwards, a written consent from the subjects

for their willingness to be a part of the intervention was obtained. Under the medical supervision, blood samples were drawn by a trained technician and analyzed for Haemoglobin (Hb). Anthropometric measurements such as height, weight, waist circumference (WC) and hip circumference (HC) were also taken using standard methods [12]. For the dietary assessment of subjects, their food intake was obtained for three days using 24-hour recall method and nutrients were calculated using Diet Cal software [13]. All the parameters were assessed pre and post intervention for both the groups.

Dietary intervention

A dietary intervention to assess the efficacy of the mixture on the health and nutritional profile of the subjects was carried out for a period of 120 days. The subjects of the intervention (I) group were provided with the formulated mixture packets on weekly basis (100 g of mixture to be consumed daily). This mix could meet almost 1/3 of their daily energy and protein requirements. They were demonstrated about the preparation of food products from this mixture before the start period of intervention. They were guided to consume these food products on daily basis according to their convenience along with their routine diet. Along with the mixture, the selected subjects were also given nutrition education on fortnight basis during the period of intervention, while the delayed intervention (DI) group was not provided with any kind of mixture/counselling. The continuous monitoring of the subjects was done by keeping in touch with them through phone calls, text messages and WhatsApp application. Various nutritional and health parameters including dietary intake, anthropometry and biochemical profile of both the groups were assessed pre and post intervention.

Statistical analysis

All the collected data was subjected to statistical analysis by calculating means and standard deviations. The organoleptic characteristics of the modified products were compared to those of the control ones using paired t-test. Similarly, the pre and post intervention data of the selected subjects was compared using t-test. (SPSS)

Results and Discussion

Sensory evaluation of the developed products

Three food products namely, *panjiri*, *gulgule*, *mithi roti* were developed from the RTU mix. The organoleptic scores are presented in figure 1. All these products showed overall higher acceptability i.e., 8.1, 8.2 and 8.1, respectively, when compared to their control counterparts (which were prepared from only wheat flour as per traditional Punjabi recipes) with values being 7.8, 7.6 and 7.4, respectively. The higher acceptability of the modified products might be due to the addition of the pulses and oilseeds etc., which could contribute to improvement in texture, taste and flavor of the products. Similar results of high overall acceptability of Upma from RTU mixture by addition of pulses to the semolina have also been reported [14].

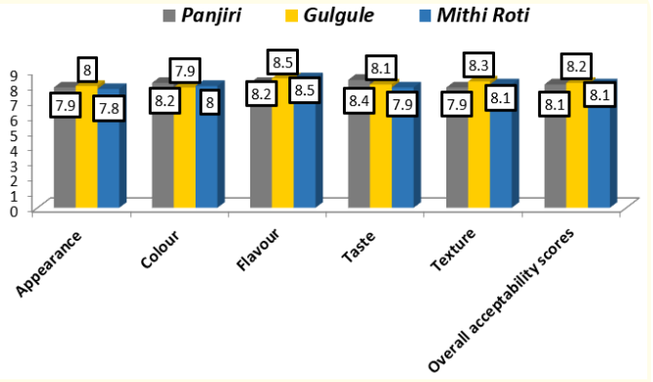

Figure 1: Organoleptic scores of the culturally suitable food products prepared from RTU nutrient dense mix.

Nutrient composition of the RTU mixture and products developed with RTU mixture.

Indian Pulse and Grain Association has portrayed pulses as the future ingredient to commensurate the nutritional and health benefits on India Food Security Portal by virtue of their richness in plant protein, energy, dietary fiber, a wide variety of micronutrients and bioactive compounds [15].

As stated earlier, in the present investigation the wheat flour was partially replaced with the pulse flours with a purpose to make it more nutritious. It contained 22.1g protein, 341.8 Kcal energy and micronutrients such as calcium, iron and zinc 69.71, 4.81 and 2.91 mg/100g, respectively. However, in comparison to this, the wheat flour which is used traditionally for the preparation of above-mentioned products contained 10.57 g of protein, 30.94 mg of Ca and 4.10 mg of Iron per 100g [16]. Similarly, chickpea based novel RUTF also contained 12.42 percent crude protein, 31.33 percent crude fat and 3.17 percent dietary fibre [17]. In another study, "RUTF Agra" was formulated using equal amounts of peanuts, puffed rice, Bengal gram and jaggery to be used for hospitalized children in nutritional rehabilitation, which was found to have 9.5 percent protein, 26.25 percent fat and 62 percent carbohydrates [18]. The comparison of the findings of the present study with those from the literature revealed that the multigrain mixes always have better nutritional profile than when a single grain is used for the preparation of food products.

The nutritional composition of products (Table 2) showed that the protein and carbohydrate content of the *panjiri*, *gulgule* and

Nutrients	RTU Nutrient dense mix	Panjiri	Gulgule	Mithi roti
Moisture (%)	5.2 ± 0.05	2.7 ± 0.08	3.21 ± 0.05	3.8 ± 0.04
Protein (%)	22.1 ± 0.24	17.1 ± 0.74	16.6 ± 0.74	16.1 ± 0.74
Ash (%)	2.5 ± 0.06	1.1 ± 0.42	2.1 ± 0.04	2.0 ± 0.08
Fat (%)	2.6 ± 0.19	22.9 ± 1.18	3.87 ± 0.43	3.2 ± 0.38
Energy (kcal)	341.8	462.1	359.2	353.6
Total Carbohydrates (%)	57.5	46.9	64.5	65.1
Crude fibre (%)	10.1 ± 0.15	9.2 ± 0.31	9.7 ± 0.16	9.8 ± 0.24
Iron (mg)	4.81	3.65	4.01	3.93
Calcium (mg)	69.71	78.24	64.21	73.80
Zinc (mg)	2.91	2.68	2.93	2.87

Table 2: Nutritional Composition of the RTU nutrient Dense Mixture and of the products.

mithi roti was 17.1, 16.6 and 16.1 and 46.9, 64.5 and 65.1 percent, respectively. The calcium, iron and Zinc content in *gulgule* and *mithi roti was* 64.21 and 73.8mg, 4.01 and 2.93 mg and 3.93 and 2.87 mg/100g, respectively. These products can be considered as good sources of the macro and micronutrients, which might be due to the addition of a diverse kind of ingredients in the RTU mixture from which these products were prepared. The developed energy dense *laddu* using soy flour, rice, groundnut, puffed Bengal gram flour, milk powder, sugar powder and ghee showed that the food product have 9.8g of protein, 31.6 g of fat and 516 kcal of energy per 100g [19].

Impact of intervention of the RTU mixture on selected undernourished subjects

Prior to the intervention, data regarding socio- economic status of the selected subjects was assessed which included age, marital status, type of family, educational qualification, land holding, occupation, family monthly income and meal type. Socio-economic profile and dietary habits of the selected undernourished women are presented in table 3. Both the groups i.e., Intervention and Delayed Intervention were matched on the basis of their socio-economic status. About 40 percent of the undernourished subjects in both groups were from the age group of 30-40 years. Majority of the subjects in both the groups were only literate (90% in DI and 96.7% in I group) i.e., they knew only how to read and write and had no formal education. More than 50 percent of the subjects in both groups belonged to low-income group and were landless. Low educational status was observed to be predominating factor among the subjects which can be one of the reasons for the low income and poor quality of life of the families. Low household education levels, including women's education, coupled with lack of nutrition awareness and marginalization in access to health care, may influence their health behaviours [20]. All the subjects were vegetarian with majority i.e., 63.3 percent consuming three meals per day.

Effect of dietary intervention on food and nutrient intake of selected subjects

The data regarding food and nutrient intake of the selected subjects was collected pre and post-intervention The data is presented in table 4 and 5. A significant ($p < 0.05$) increase in the per cent adequacy of cereal (from 66.31 to 71.94%), pulses (from 57.76 to 79.96%), sugars (from 55.35 to 93.75%) and fats (from 41.85 to 96.3%) was observed among the subjects of I group. This increase might be due to the incorporation of cereals, pulse, fat and sugars in their daily diets by the food products prepared from the RTU multigrain mix. Further, an increase in the percent adequacy of roots and tubers (from 15.72 to 21.08%), fruits (from 16.61 to 23.96%), milk and milk products (from 34.08 to 54.85%) was also observed among the Intervention group. This increase in the consumption of various food groups might be due to impact of nutrition education provided to the subjects on a regular basis. Similar results, in a study of Korean students, showed that the combination of nutrition education and supplement provision was significantly beneficial in improving body composition, dietary habits, daily nutrient intake, and quality of life [21]. On contrary to this, the cereal, pulses, green leafy vegetables intake reduced significantly in the delayed intervention group. It was observed that the due to inadequate food intake, the percent adequacy for the macro and micronutrients was also inadequate before the initiation of the dietary intervention. The data analysis from the NNMB India dataset (2011-2012) concluded that the major contributor of dietary energy was carbohydrates (75%) and the fat intake was less than optimal (14%), and almost all the Indian adolescent girls and adult women did not satisfy the criterion for AMDR of energy from carbohydrates (50-60%), proteins (10-15%), or fats (20-30%) [20]. After the intervention of 120 days, the mean intake of protein, fat and carbohydrates increased from 25.87 ± 6.13g, 12.76 ± 2.87g and 129 ± 33.65g to 40.36 ± 7.69 g, 20.1 ± 4.32g and 163.2 ± 35.04g, respectively in the intervention group. This increase may be due to the nutrient dense

Parameter	Intervention group (I) (n_1 = 30)	Delayed Intervention group (DI) (n_2 = 30)
Age		
< 30	8 (26.7)	7 (23.3)
30-40	12 (40.0)	12 (40.0)
>40	10 (33.3)	11(36.7)
Marital status		
Married	27 (90.0)	28 (93.3)
Unmarried	3 (10.0)	2 (6.7)
Type of family		
Joint	27 (90.0)	23 (76.4)
Nuclear	3 (10.0)	7 (23.3)
Educational qualification		
Illiterate	3 (10.0)	1 (3.3)
Literate	27 (90.0)	29 (96.7)
Primary	2 (6.7)	2 (6.7)
Middle	2 (6.7)	3 (10.0)
High school	7 (23.3)	11(36.7)
Graduation	3 (10.0)	4 (13.3)
Postgraduate	-	-
Other	11 (36.7)	9 (30.0)
Land holding		
Landless	16 (53.3)	17 (56.7)
Marginal (< 2 hec)	11 (36.7)	9 (30.0)
Small (3-5 hec)	3 (10.0)	4 (13.3)
Large (> 5 hec)	-	-
Occupation		
Employed	21 (70.0)	23 (76.7)
Non employed	9 (30.0)	7 (23.3)
Family Monthly Income (Rs.)		
Lower < 2640	-	-
Upper lower 2641-7886	16 (53.3)	20
Lower middle 7887-19758	14 (46.7)	10 (33.3)
Upper middle 19756-26354	-	-
Higher >52734	-	-
Meal type		
Vegetarian	30 (100.0)	30 (100.0)
Non vegetarian	-	-
No. of meals		
1	-	-
2	11 (36.7)	11 (36.7)
3	19 (63.3)	19 (63.3)
4	-	-

Table 3: Socio-economic profile and dietary habits of the selected undernourished women. (N = 60).
*Values in parenthesis indicate percentages.

	Intervention group (n_1 = 30)						Delayed Intervention group (n_2 = 30)				
Food groups	**RDA**	**Pre**	**% Adequacy**	**Post**	**% Adequacy**	**t-value**	**Pre**	**% Adequacy**	**Post**	**% Adequacy**	**t-value**
Cereals	270	179.04	66.31	194.23	71.94	6.248	177.8	65.85	150.6	55.78	5.071
Pulses	55	31.77	57.76	43.98	79.96	11.654	33.47	60.85	30.58	55.6	7.982
Green leafy vegetables	100	26.73	26.73	22.08	22.08	3.801	20.7	20.7	12.4	12.4	6.216
Other vegetables	200	46.58	23.29	58.91	29.46	2.004^{NS}	49.32	24.66	45.21	22.61	1.963^{NS}
Roots and Tubers	200	31.44	15.72	42.17	21.08	5.987	30.82	15.41	45.61	22.81	3.057
Fruits	100	16.61	16.61	23.96	23.96	7.254	15.07	15.07	13.78	13.78	2.009^{NS}
Milk and milk product	300	102.23	34.08	164.54	54.85	10.057	92.14	30.71	115.14	38.38	7.366
Sugars	20	11.07	55.35	18.75	93.75	15.0634	11.97	59.85	13.89	69.45	8.457
Fat	20	8.37	41.85	19.26	96.3	16.084	8.79	43.96	10.55	52.73	7.364

Table 4: Impact of dietary intervention on the dietary intake of the selected subjects.

(N = 60).

Nutrients	Intervention group (n_1 = 30)						Delayed Intervention group (n_2 = 30)				
	RDA	**Pre**	**% Adequacy**	**Post**	**% Adequacy**	**t-value**	**Pre**	**% Adequacy**	**Post**	**% Adequacy**	**t-value**
Protein (g)	55	25.87 ± 6.13	47.04	40.36 ± 7.69	73.39	12.047	28.06 ± 8.20	51.01	34.4 ± 12.28	62.55	2.946
Fat (g)	25	12.76 ± 2.87	51.03	20.1 ± 4.32	80.38	10.993	20.23 ± 5.18	80.93	20.68 ± 4.41	82.72	1.074^{NS}
CHO (g)		129 ± 33.65		163.2 ± 35.04		11.846	142.2 ± 43.29		139 ± 43.39		0.587^{NS}
Energy (Kcal)	2230	1234 ± 166.7	55.34	1578 ± 170.8	70.77	17.88	1363 ± 226.9	61.12	1380 ± 205.8	61.87	0.660^{NS}
Calcium (mg)	600	318 ± 102.4	53.03	486.3 ± 117.2	81.05	12.694	326.3 ± 97.84	54.39	347.5 ± 71.21	57.92	1.231^{NS}
Iron (mg)	21	8.22 ± 2.33	39.12	12.28 ± 2.62	58.47	13.728	8.83 ± 2.75	42.06	8.56 ± 2.39	40.77	1.166^{NS}
Zinc (mg)	10	4.06 ± 1.32	40.55	5.16 ± 1.44	51.62	9.793	4.54 ± 1.59	45.39	4.51 ± 1.45	45.06	0.218^{NS}

Table 5: Impact of dietary intervention on the nutrient intake of the selected subjects.

(N = 60).

mixture provided to the intervention (I) group. The calcium, iron and zinc intake of the I group also increased significantly ($p < 0.05$). In the DI group, there was non-significant increase in the fat, carbohydrates, energy and calcium intake of the subjects.

Effect of dietary intervention on anthropometric parameters of selected undernourished subjects

It has been reported that consuming conventional snacks especially pulse-based healthy snacks have numerous health benefits. [22] The anthropometric and biochemical parameters of selected undernourished subjects pre and post intervention are presented in table 6. After the intervention trial for 4 months, the weight of the intervention group subjects increased significantly ($p < 0.05$) from 42 ± 2.92 to 45.89 ± 3.41 Kg, thereby increasing the body mass index (BMI) from 16.98 ± 1.05 to 18.74 ± 1.26 kg/m^2, which falls in the normal category as per WHO classification of body mass index for Asians. This gain in weight can be attributed to the additional energy and protein provided through the supplementation of the products (*panjiri/gugule/mithi roti*) in the daily diets. Similar findings were observed in the study indicating increase in body weight of selected farm women with additional calories and protein through energy dense *laddo* along with their regular diet [19]. There was a significant increase in the waist (from 62.5 ± 5.91 to 65.31 ± 5.95 cm) and hip circumference (from 79.78 ± 6.69 to 82.43 ± 6.78 cm) of the intervention group subjects. In contrast, there was a non-significant decrease in the weight, BMI and hip circumference of delayed intervention group subjects. Further, a significant increase ($p < 0.05$) in the haemoglobin from 9.93 ± 1.36g/

Anthropometric measurements	Intervention group (n_1 = 30)				Delayed Intervention group (n_2 = 30)			
	Pre	Post	Difference	't' value	Pre	Post	Difference	't' value
Height (cm)	1.62 ± 0.06	1.62 ± 0.06	-	-	1.57 ± 0.08	1.57 ± 0.08	-	-
Weight (Kg)	42 ± 2.92	45.89 ± 3.41	-3.89 ± 1.37	15.516	39.92 ± 4.62	38.91 ± 4.52	1.01 ± 1.59	1.472^{NS}
BMI (kg/m2)	15.98 ± 1.05	17.47 ± 1.26	-1.48 ± 0.54	14.901	16.12 ± 0.92	15.72 ± 1.05	0.39 ± 0.66	1.264^{NS}
WC (cm)	62.5 ± 5.91	65.31 ± 5.95	-2.81 ± 0.93	16.430	61.59 ± 6.75	61 ± 6.46	0.59 ± 1.54	2.008^{NS}
HC (cm)	79.78 ± 6.69	82.43 ± 6.78	-2.65 ± 1.003	14.490	79.12 ± 7.38	78.72 ± 7.19	0.40 ± 1.45	1.511^{NS}
WHR	0.78 ± 0.03	0.79 ± 0.03	-0.01 ± 0.01	4.722	0.778 ± 0.04	0.775 ± 0.04	0.003 ± 0.01	1.584^{NS}
Hb. Level(g/dl) Normal 11.5-16.5	9.93 ± 1.36	10.47 ± 1.22	0.54	6.121	10.1 ± 1.29	9.98 ± 1.104	0.12	1.028^{NS}

Table 6: Impact of dietary intervention on anthropometric parameters and haemoglobin level of the selected subjects. (N = 60).

dl to 10.47 ± 1.22g/dl was observed in the intervention group. Another study conducted in Indonesia revealed that the nutrition education along with supplementation of multi-nutrient biscuit to under five undernourished children for the period of 6 months proved to be effective in weight gain and increased serum ferritin levels of the beneficiaries [23].

In the past literature much work has been done on the supplementation and improvement in the nutritional status of the children, but the impact of supplementation on that of women and that too, in the form of regionally acceptable foods has not been explored much. However, it has been suggested by UNICEF also that by Improving the quantity and nutrient level of food consumed in the household and by imparting knowledge to improve the local diet, production and household behaviours through nutrition and health education, the nutritional status of this vulnerable section of the society (i.e., women of reproductive age) can be improved.

Conclusion

The rural population especially the women, due to lack of awareness and knowledge, has become most vulnerable targets of malnutrition in terms of nutrient deficiencies. In order to reduce the incidence of undernourishment among rural women, a food-based approach such as inclusion of cost effective and locally available nutritious food sources has become crucial, which will not affect their purchasing power. The RTU multigrain mixture developed in this study was easy to prepare and consume with a right balance of energy and protein, so when supplemented in the daily diets of the selected population, it significantly improved their nutritional status. Therefore, the study recommends for a long- term supplementation of the RTU nutrient dense mixture along with nutrition education to attain more comprehensive long-term benefits.

Conflict of Interest

The authors declare that they have no conflicts of interests in this work.

Ethical Guidelines

Prior permission for this research was obtained from Institutional ethical committee of Punjab Agricultural University vide letter No. DR/2018 13632-44 dated 12.07.18.

Bibliography

1. Nubé M and Van Den Boom GJM. "Gender and adult under nutrition in developing countries". *Annals of Human Biology* 30.5 (2003): 520-537.

2. James PT., *et al.* "Women's nutrition: A summary of evidence, policy and practice including adolescent and maternal life stages". Emergency Nutrition Network (ENN): Kidlington, Oxford, UK (2022).

3. Agugo UA., *et al*. "Influence of Workload and Feeding Pattern on the Nutritional Status of Rural Women Farmers in Nkwere LGA of Imo State, Nigeria". *Journal of Nutrition and Food Sciences* 7.2 (2017): 608.

4. Obada A A., *et al* . Hyper Prevalence of Malnutrition in Nigeriaen Context. Biomedical journal of scientific and Technical Research (2021): 30917-30925. DOI: 10.26717/BJSTR.2021.39.006237.

5. Corsi DJ., *et al*. "Risk factors for chronic undernutrition among children in India: Estimating relative importance, population attributable risk and fractions". *Social Science and Medicine* 57 (2016): 165-185.

6. Young MF., *et al.* "A Double-Edged Sword? Improvements in Economic Conditions over a Decade in India Led to Declines in Undernutrition as Well as Increases in Overweight among Adolescents and Women". *The Journal of Nutrition* 150.2 (2020): 364-372.

7. Usmani G and Ahmad N. "Health status in India: A study of urban slum and non-slum population". *Journal of Nursing Research and Practice* 2 (2018): 09-14.

8. NFHS-5 (2019-21) National Family Heath Survey V. International Institute for Population Sciences (IIPS), Ministry of Health and Family Welfare, Government of India (2021).

9. Rangana S. "Handbook of analysis and quality control for fruit and vegetable products". Tata McGraw Hill Publishing Company Limited, New Delhi (2002).

10. AOAC. "Official methods of analysis. 25th edition". Association of Official Analytical Chemist, Washington (2010).

11. Piper CS. "Soil and plant analysis". Inter-science Publication Inc., New York (1950): 212-215.

12. Jelliffe DB. "The assessment of the nutrition status of the community". World Health Organization: Monograph Series Geneva 53 (1966): 50-84.

13. Kaur G. "Diet Cal software-a tool for dietary assessment and planning". All India Institute of Medical Sciences, New Delhi (2014).

14. Seth K and Singla N. "Organoleptic, Nutritional and Shelf Stability Analysis of Formulated Nutrient Dense Ingredient Mix". *Chemical Science Review and Letters* 11.4 (2022): 91-103.

15. Longvah T., *et al.* "Indian food composition tables". National Institute of Nutrition Indian Council of Medical Research Publishing, Hyderabad (2017).

16. Agrawal A and Varma K. "Diet and nutrient intakes in urban women of Rajasthan State, Northern India". *Ecology of Food and Nutrition* 55 (2016): 16-29.

17. Hassan JU., *et al.* "Development, efficacy and comparative analysis of novel chickpea based ready-to-use therapeutic food". *Japs: Journal of Animal and Plant Sciences* 26.6 (2016): 1843-1849.

18. Sandeep S and Mona V. "Nutritional rehabilitation using energy dense local food as ready to use therapeutic food in hospitalized malnourished children: Case for primary prevention at grass root levels". *Journal of Medicine in the Tropics* 16.1 (2014): 22-26.

19. Geetha K., *et al*. "Impact of Dietary Intervention on Undernourished Farm Women". *The Pharma Innovation Journal* SP-11.2 (2022): 28-33.

20. Radhika MS., *et al.* "Dietary and nondietary determinants of nutritional status among adolescent girls and adult women in India". *Annals of the New York Academy of Sciences* 1416.1 (2018): 5-17.

21. You JS., *et al.* "Evaluation of 8-week body weight control program including sea tangle (Laminaria japonica) supplementation in Korean female college students". *Nutrition Research and Practice* 3.4 (2009): 307-314.

22. Gurusamy S., et al. "Pulses for Health and Their Varied Ways of Processing and Consumption in India - A Review". *Applied Food Research* 2.2 (2022): 100171.

23. Ahmad A., *et al.* "Effect of nutrition education and multi-nutrient biscuit interventions on nutritional and iron status: A cluster randomized control trial on undernourished children aged 6-23 months in Aceh, Indonesia". *Journal of Nutritional Science and Vitaminology* 66 (2020): S380-S390.