Research Article

Organoleptic, Nutritional and Shelf Stability Analysis of Formulated Nutrient Dense Ingredient Mix

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Abstract

In this fast paced world, a healthy meal or snack which requires minimum efforts and time to be cooked is highly in demand. Keeping this in view, an attempt was made to develop a nutritious, locally available, cost effective, ready-to-cook product. After rigorous organoleptic evaluations, Nutrient Dense Ingredient Mix (NDIM) was formulated with semolina (*suji*), pearl millet (*bajra*), whole green gram (*sabut moong dal*), dried fenugreek leaves, peanuts, fat, turmeric powder (*haldi*), cumin seeds (*jeera*), red chilli powder and salt. The best combination that was standardized based on multiple rounds of sensory evaluations was then tested for nutritional composition as well as shelf stability. Roasting was selected as the most suitable treatment since germination did not fulfill the appropriate sensory requirements. The developed mix was found to be energy dense as 100g of cooked NDIM provided 437.4 Kcal of energy, 13.58g protein and 3.62mg of iron and could be stored well upto 3 months in an air tight glass jar under ambient conditions.

Keywords: Nutrient dense ingredient mix, Ready-to-cook, Ready-to-use, Organoleptic evaluation, *Upma*, Shelf life

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Introduction

Choice of food is not a one-dimensional approach, instead it is based on ~~a~~ complex human behavior and influenced by many interrelated factors. Extensive research studies with regard to nutrition and consumer perception have reported that food preference is governed by both nutrition and the pleasure associated with food consumption. Beliefs pertaining to health effects of a food product could be more dominant in influencing a person's choice of food than the actual nutritional and health consequences [1]. Since early times, aboriginal instant food products were prepared at home only, but due to the increasing affordability and easy availability of wide range of instant food products in recent years, consumers are more interested in using the commercially available food products presented in convenient packaging [2]. These days the market is flooded with nutritious, cost effective variants of convenience foods. These variants may be termed as Ready-to-use (RTU)/ Ready-to-eat (RTE)/ Ready-to-cook (RTC)/ Ready-to-serve (RTS) etc. depending upon their nature and time required for consumption [3]. The major shift to convenient foods can be attributed to the requirement of balanced nutrition and time- efficient preparations in the hectic lifestyles of the progressive working class [4] along with the increased working hours and better spending power [5]. This change in food consumption behaviour has led to the exploration and acceptance of different food ingredients, thereby increasing food choices [6]. These choices largely depend upon the value proposition, the food has to offer in terms of variety, taste, health benefits, nutrition. It was also observed that the major reasons for buying RTE foods were sensory appeal, affordability, convenience and mood of the consumer [7]. Commercially available 'Ready-to-use therapeutic food' (RUTF) provide a combination of easily accessible macronutrients, along with the essential minerals and vitamins. These are highly energy-dense and do not need to be mixed with water, rendering them as an appropriate choice for the treatment of severe acute malnutrition [8].

It can thus be concluded that the RTC foods have emerged as an excellent alternative to a complete home-cooked meal or may be an addition to the daily diet. Its consumption trends are hiking due to an increase in working women population [9]. Millets are in trend and sought after as they add a nutritious addition to these mixes. As per the consumer liking for various RTC forms of millets, powder mixes of *idli* and *dosa* were highly chomped followed by powder forms (roti-mix), millet *rava*, *upma* mix, porridge, noodles, vermicelli and millet muesli in the line [10].

According to a food health survey conducted by The International Food Information Council (IFIC) in 2018 it was reported that 23 per cent of customers prefer diet containing natural ingredients for their wellbeing. Thus, it is evident that importance is being given to the ingredients, their sourcing and the treatment processes setting a base for the clean label trend [11].

With this background, the present study was designed wherein Nutrient Dense Ingredient Mix (NDIM) was formulated with ingredients from locally sourced traditional food groups. NDIM consisted of a well-balanced and measured proportion of a cereal, millet, pulse, oilseed, green leafy vegetable fat and spices. The processing treatments and quantities of ingredients finalised after preliminary testing and sensory analysis rendered the final ready-to-cook product as energy dense, nutritious and convenient, the flavour and texture being somewhat similar to that of *upma*. The NDIM was further evaluated for its nutritional composition and shelf life.

Materials and Methods

Procurement and processing of raw ingredients

Semolina (*suji*), pearl millet (*bajra*), bengal gram (*kala chana*), chick peas (*kabuli chana*), whole green gram (*sabut moong dal*), vegetable (fenugreek leaves), peanuts, fat, turmeric powder (*haldi*), cumin seeds (*jeera*), red chilli powder, salt were procured form the local vendors and market in Ludhiana. Procured sample of cereals, millets, pulses and other ingredients were cleaned, extraneous matter was removed for further processing. Various combination trials of millets, pulses/legumes, vegetables, oilseeds, condiments and spices with wheat variants (semolina and broken wheat) as the base product were attempted using different treatments such as roasting, germination etc. in such a way that the formulated mixture required minimum cooking before consumption. Fresh fenugreek leaves were subjected to dehydration for incorporation into the mixture.

Preliminary trials

Preliminary studies were performed for the purpose of identifying the tentative proportion of ingredients, sample combinations, processing treatment and cooking methods for further sensory evaluation. Several compositions of raw materials and main ingredients were tried to arrive at the desired formulation with optimum percentage as recommended by acceptability studies. The quantity for incorporation and appropriate treatment to be applied to these ingredients was standardized at initial stages using roasted semolina as the base for the trials. For the incorporation of millet, oilseed and vegetable in 100g NDIM, pearl millet (5g), peanuts (10g) and dried fenugreek leaves (10g) were selected respectively as the best choice through preliminary testings. The combination cooked with 15g fat provided desirable texture and softness to the cooked mixture.

Standardisation of variants of Nutrient Dense Ingredient Mix

Nutrient Dense Ingredient Mix was standardised after the developed formulations were organoleptically evaluated by a panel of 10 semi-trained judges from Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana. Judges were asked to score the samples for their colour, appearance, flavour, texture, taste and overall acceptability using a score card of 9 point hedonic rating scale (9- like extremely to 1- dislike extremely). Each product was tested for its Appearance, Colour, Texture, Flavour, Taste and Overall acceptability and mean scores were calculated for acceptability and selection of the final product i.e. Nutrient Dense Ingredient Mix (NDIM) for further analysis.

Consumer acceptability

Twenty five participants (18-50 yrs) were selected from the areas in and around Punjab Agricultural University, Ludhiana for analyzing the acceptability of developed Nutrient Dense Ingredient Mix (NDIM) among the masses. For this purpose, 'likert scale' with five point rating was used.

Nutritional evaluation

Developed products (dried) were thoroughly mixed in a blender and weighed quantity of sample was dried in oven at (60±20ºC) in petri dishes. The dried sample was then ground to fine powder for further analysis of parameters including proximate composition, β – carotene, minerals, *in-vitro* nutrient digestibility and anti-nutritional factors. The proximate composition of the prepared product was determined using the standard methods [12]. The total calcium and iron were estimated using Piper's method [13]. Parameters like ionisable iron, β – carotene, *in vitro* carbohydrate and protein digestibility were determined using the methods given by Rao and Prabhavati (1978), Rangana (1995), Bernfeld (1954) and Akeson and Stachman (1964) respectively [14-17]. Presence of anti-nutritional factors like phytin phosphorous and oxalates was estimated as per the methods mentioned by Haug and Lantzsch (1983) and Abeza et al. (1968) respectively [18, 19].

Shelf life evaluation

Shelf life of the developed NDIM was evaluated by storing the mixture (100g each) in three different type of air tight packaging materials i.e. polyethylene zip lock pouches, plastic containers and glass jars for 4 months under ambient conditions (25-35°C). Standard procedures were followed to analyze changes in the moisture [12], free fatty acid content (% oleic acid) [20], peroxide value [21], microbial analysis [22] and organoleptic evaluation after a regular interval of one month.

Results and Discussion

Organoleptic evaluation of variants of Nutrient Dense Ingredient Mix

Selection of base ingredient

Table 1 represents the score of organoleptic evaluation for the selection of base (roasted semolina /roasted broken wheat) of NDIM. Six combinations were developed with roasted semolina, roasted broken wheat, roasted pulses, legumes and other ingredients. The mixtures with roasted semolina as the base were inferred as the acceptable ones rejecting the ones with broken wheat (raw *daliya*) base as broken wheat granules imparted an uncooked, raw texture, flavor and mouth feel. The selected combination gave an *upma* like texture, appearance and flavor.

Table 1 Organoleptic characteristics of Nutrient Dense Ingredient Mix (NDIM) for selection of the base ingredient (semolina *vs* broken wheat)

Sample	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
SB	7.2±0.79	7.2±0.79	6.5±0.97	6.6±0.52	6.6±0.7	6.7±0.48
SC	6.5±0.71	6.5±0.71	6.1±0.88	6.5±0.71	6.5±0.85	6.3±0.48
SG	7.6±0.7	7.6±0.7	7±1.25	7.1±0.88	7.1±0.99	7.2±0.79
BB	5.6±0.52	6.1±0.99	5.1±1.2	5.6±0.7	5.5±0.71	5.6±0.52
BC	5.8±0.63	6.1±0.88	5.3±1.34	5.4±0.84	5.1±0.74	5.6±0.7
BM	6.5±0.85	6.8±0.79	6±1.7	6.5±0.97	6.2±1.23	6.3±1.06
Kruskal Wallis H – Test χ^2 value	31.02***	19.75***	19.37***	22.32***	23.64**	24.80***

Values are expressed as Mean ± SD; ***Significant difference at 1% level of significance ($p<0.01$)
** Significant difference at 5% level of significance ($p<0.05$)
SB – Semolina + Bengal gram; SC – Semolina + Chick peas; SG – Semolina + Green gram; BB – Broken wheat + Bengal gram; BC –Broken wheat + Chick peas; BG – Broken wheat + Green gram

Selection of most acceptable pulse/legume with suitable treatment

Roasting reduces the moisture content while improving texture as well as keeping quality of the food product [23]. On the other hand it is a well known fact that germinated pulses and legumes show enhanced nutritional quality along with the increase in bioactive compounds and reduction in anti-nutritional components [24]. Keeping in view the ease of application and benefits of both the processing methods, 10g of roasted and germinated bengal gram, chick peas and whole green gram were incorporated respectively in the mixture with roasted semolina as the base (selected from the previous evaluation). The mixture with roasted whole green gram turned out to be the most acceptable one (**Table 2**).

Selection of level of whole green gram

Germination is regarded as a simple and inexpensive technique known to improve the palatability, digestibility and availability of certain nutrients [25]. Also, the effect of germination depends on the type, conditions and duration germination process of pulse [26]. Though roasted green gram was selected as the most acceptable pulse and treatment in the previous organoleptic evaluation but owing to the multiple benefits of germination, germinated lot of whole green gram was again incorporated into the mixture to explore any possibilities for the selection of this treatment. So as to optimize the quantity of green gram dal in the mixture six variants were prepared with 10g, 15g and 20g of incorporation of germinated and roasted whole green gram each. The overall scores (**Table 3**) for roasted green gram samples were comparatively higher than their germinated counterparts which can be accounted to the fact that germination renders a dark color and a comparatively non appealing texture, the same was reported by Kikafunda et al. (2006) [27].

Table 2 Organoleptic evaluation of Nutrient Dense Ingredient Mix (NDIM) for the selection of most acceptable treatment of pulse/legume

Sample	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
RB	8.2±0.79	8.2±0.79	7.8±1.03	8.1±0.99	8±1.15	8±1.05
RC	8.1±0.99	8±0.94	7.8±0.79	7.7±0.82	7.7±0.82	7.9±0.88
RG	8.2±0.63	8.3±0.67	8±0.67	8.1±0.57	8.2±0.63	8.2±0.63
GB	7.6±0.97	7.6±0.97	7.4±1.07	7.4±0.97	7.4±0.97	7.6±0.97
GC	7.9±0.74	7.9±0.74	7.3±0.67	7.5±0.53	7.5±0.53	7.6±0.52
GG	8.1±0.57	8.1±0.57	8.1±0.57	8.1±0.32	8.3±0.48	8.2±0.42
Kruskal Wallis H Test χ^2 value	3.60 ^{NS}	4.10 ^{NS}	7.25 ^{NS}	9.99*	11.48**	6.52 ^{NS}

Values are expressed as Mean ± SD; ** Significant difference at 5% level of significance (p<0.05);
^{NS} Non significant difference; RB – Roasted bengal gram; RC - Roasted chick peas; RG - Roasted green gram; GB - Germinated bengal gram; GC – Germinated chick peas; GG – Germinated green gram

Table 3 Organoleptic evaluation of Nutrient Dense Ingredient Mix (NDIM) at different levels of green gram

Sample	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
RG1	7.8±1.40	7.9±1.10	7.2±1.93	7.8±0.79	7.8±0.79	7.8±0.92
RG2	7.3±1.57	7.5±0.97	6.8±1.69	7.1±0.57	7.1±0.57	7.3±0.95
RG3	6.8±1.23	6.9±0.99	6.1±1.45	6.6±0.84	6.6±0.84	6.6±0.70
GG1	6.9±1.52	7.2±0.92	6.7±1.49	6.9±0.57	6.9±0.57	7±0.94
GG2	6.4±0.97	6.6±0.70	6.2±1.23	6.6±0.84	6.6±0.84	6.5±0.53
GG3	5.7±1.06	6±0.67	5.7±1.25	6±0.94	6±0.94	5.9±0.88
Kruskal Wallis H Test χ^2 value	24.28***	24.38***	10.52**	20.48***	20.48***	22.84***

Values are expressed as Mean ± SD; ***Significant difference at 1% level of significance (p<0.01);
** Significant difference at 5% level of significance (p<0.05); RG1 – Roasted green gram (10g);
RG2 – Roasted green gram (15g); RG3 – Roasted green gram (20g); GG1 – Germinated green gram (10g);
GG2 – Germinated green gram (15g); GG3 – Germinated green gram (20g)

Optimization of water level required for reconstitution of the mix

The most acceptable formulation based on the result from previous evaluations (semolina with 10g roasted whole green gram variant) was prepared with varying ratios of sample to water (i.e. 1:1, 1:1.5, 1:2, 1:2.5) to obtain the desirable consistency after reconstitution. Based on the maximum overall acceptability score (OAA) of 8.2±0.63, the sample to water ratio of 1:1 was optimized with a significant difference from the other trials for the formulation of ready to cook NDIM (**Table 4**). In case of other ratios with increased water content, it was observed that the water stayed at the surface of the cooked product i.e. not being wholly absorbed, giving it a slurry texture which rendered it less palatable and appealing. However, maximum sensory score at the ratio 1:5.5 was observed for millet *upma*, prepared by open pan cooking [6].

Table 4 Organoleptic evaluation of the Nutrient Dense Ingredient Mix (NDIM) for optimization of water level required for reconstitution of the mix

Sample	Appearance	Colour	Texture	Flavour	Taste	Overall Acceptability
a	8.3±0.48	8.2±0.63	7.9±1.45	8.1±0.57	8.2±0.42	8.2±0.63
b	7.7±0.67	7.6±0.70	7.4±1.26	7.6±0.52	7.7±0.48	7.7±0.48
c	7.5±0.85	7.4±0.84	7.1±1.45	7.4±0.97	7.5±0.97	7.4±0.97
d	6.5±0.53	6.3±0.67	6.1±0.99	6.2±0.79	6.2±0.79	6.3±0.82
Kruskal Wallis H Test χ^2 value	21.57***	20.00***	14.05**	19.52***	21.95***	19.45***

Values are expressed as Mean ± SD; ***Significant difference at 1% level of significance (p<0.01);
** Significant difference at 5% level of significance (p<0.05); a – 1:1 (sample:water);
b – 1:1.5 (sample:water); c – 1:2 (sample:water); d – 1:2.5 (sample:water)

The overall texture, mouthfeel and other sensory attributes of the final cooked product were quite like that of *upma*, a traditional indian dish cooked as a thick porridge, generally from dry-roasted semolina. **Table 5** represents the composition of the most acceptable combination and **Figure 1** provides a flow chart for the preparation of mix and a picture of the cooked Nutrient Dense Ingredient Mix (100g) (**Figure 2**).

Table 5 Composition of the most acceptable combination of Nutrient Dense Ingredient Mix (NDIM)

Ingredients	Quantity (g)
Semolina	45
Pearl millet	5
Whole green gram	10
Fenugreek leaves	10
Peanuts	10
Cumin seeds	2
Turmeric powder	1
Red chilli powder	0.5
Black pepper	0.5
Salt	1
Fat	15
Water	100ml

Roast raw materials separately
↓
Heat fat in an open pan
↓
Sauté pre-roasted ingredients along with spices for 4-5 minutes
↓
Add dried fenugreek leaves and mix well
↓
Add boiling water immediately
↓
Cover with a lid and keep it aside for 1-2 minutes
↓
Nutrient Dense Ingredient Mix is now ready to eat

Figure 1 Flow chart showing the product preparation and picture of the cooked Nutrient Dense Ingredient Mix (100g)

Figure 2 Cooked Nutrient Dense Ingredient Mix (100g)

Consumer acceptability

The results for consumer acceptability are represented graphically in **Figure 3**. The results indicated that maximum number of respondents (68%) 'strongly liked' the Nutrient Dense Ingredient Mix whereas 16 per cent only 'liked' the mixture, 4 per cent of them 'disliked' the product. None of the participants responded with the option of 'strongly disliked' for the NDIM.

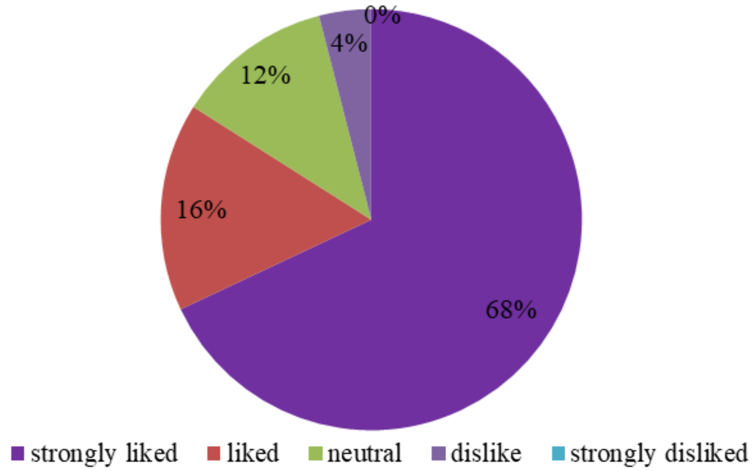

Figure 3 Consumer acceptability of Nutrient Dense Ingredient Mix (N=25)

Nutritional evaluation of Nutrient Dense Ingredient Mix

Proximate composition

Proximate composition of raw and cooked Nutrient Dense Ingredient Mix has been presented in **Table 6**. Moisture content of the raw NDIM was 5.57 per cent whereas that of the cooked form was found to be 7.88 per cent. Maske and co-workers (2020) analysed the moisture content of instant *UPMA* mix where in the control sample had a moisture content of 6.12 per cent and that of the other formulations treated with varying compositions of wheat semolina, bengal gram semolina, soya semolina and spice mix, ranged from 6.81 to 7.52 per cent. Crude protein content of the raw and cooked NDIM was found to be 11.42 and 13.58 per cent respectively. The protein content in the mix can be attributed to the incorporation of pulse (whole green gram), oilseed (peanuts) with selected millet grain (pearl millet) which are a considerable source of proteins [2]. On a similar line, Yadav and Sharma (2008) reported that soy-fortified instant *upma* dry mix had double the protein content (16.2%) as compared to *upma* prepared from wheat semolina alone. Ash content of the NDIM was observed to be 3.13 per cent and 2.59 per cent for its raw and cooked form on dry weight basis [28]. Wang et al. (2010) stated that the decrease in ash content could have resulted from diffusion of certain minerals into the cooking water. The developed NDIM was composed of 6.38 per cent fat in the raw form and 17.56 per cent in the cooked one. The increase in the fat content was due to the addition of fat while cooking the mix, the good amount of fat rendered the mixture energy dense [29]. Rodge et al. reported fat content ranging from 7.30 to 16.80 per cent in instant *UPMA* mix incorporated with foxtail millet and garden cress seeds. Optimized soy-fortified instant *upma* mix had 34.0 per cent fat owing to the addition of 51.2 g vanaspati in 100 g of total *sooji* (semolina). In the present study, crude fibre content was found to be 3.56 per cent and 4.72 per cent in raw and cooked NDIM respectively [3]. A study on the nutritional analysis of instant *UPMA* mix developed with different compositions of foxtail millet semolina and garden cress semolina revealed the fiber content to be ranging from 3.90 to 4.31 per cent which were much similar to our results [3]. Results derived from calculations in another study revealed that the raw NDIM had 69.94 per cent and cooked NDIM had 56.26 per cent of carbohydrate content. Millet *upma* exhibited a carbohydrate content of 72.48g [6]. Furthermore, the raw mix provided 382.86 Kcal of energy whereas the cooked mixture provided 437.4 Kcal per 100g of the NDIM. A similar caloric value of instant *upma* mix was reported by Rodge et al. [3]. In another study it was observed that the energy provided by developed millet *upma* was 397.33 Kcal whereas the semolina *upma* in the market (anonymous brand) provided with 411 Kcal [6].

Mineral content

Results of mineral analysis revealed that the iron, calcium and ionisable iron content of the raw mixture was found to be 2.53 mg, 36.41 mg and 1.56 mg respectively (Table 6). In case of the cooked NDIM, the iron, calcium and ionisable iron content was found to be 3.62 mg, 42.39 mg, 2.03mg/100g of the sample respectively. Tupe and Chiplonkar (2010) devised various wheat based recipes for which the mean range of calcium and iron content were 33 to 62mg and 1.3 to 4.8mg respectively. The absorption of iron from food depends upon the composition, heat treatment employed and the quantity of anti-nutritional factors like phytate, tannin, etc. present in the food samples [30]. However, the increase in the content of ionisable iron of the cooked NDIM reported in the present study was in conformity with an investigation conducted by Singh et al. (2016) where in it was observed that iron bioavailability in the food products increased upon cooking [31].

Table 6 Nutrient composition of raw and cooked Nutrient Dense Ingredient Mix (per 100g)

Nutrients	**Raw**	**Cooked**
Proximate composition		
Moisture (%)	5.57±0.18	7.88±0.16
Protein (%)	11.42±0.19	13.58±0.11
Ash (%)	3.13±0.17	2.59±0.18
Fat (%)	6.38±0.19	17.56±0.10
Fibre (%)	3.56±0.12	4.72±0.21
Carbohydrates (%) (by difference)	69.94	56.26
Energy (Kcal/100g)	382.86	437.4
Minerals		
Iron (mg)	2.53±0.14	3.62±0.29
Calcium (mg)	36.41±0.28	42.39±0.34
Ionisable Iron (mg)	1.56±0.12	2.03±0.08
Vitamins		
β – Carotene (µg)	1393.65±0.38	2248.33±0.31
In-vitro digestibility		
In-vitro Carbohydrate (%)	55±0.23	69±0.83
In-vitro Protein (%)	63±0.25	72±0.12
Anti-nutritional factors		
Phytin Phosphorus (mg)	152±0.23	97±0.36
Oxalate (mg)	69.56±0.15	38.92±0.13

Values are expressed as Mean ± SD

Vitamin content

β – carotene content was found to be 1393.65µg in 100g of raw NDIM which interestingly, increased to 2248.33µg in the cooked sample of the mixture (Table 6). This considerable amount of β – carotene content can be attributed to the fact that a significant amount of the same nutrient was present in the ingredients such as fenugreek leaves (dried) and fat (added while cooking). Sonia et al. (2020) prepared *upma* supplemented with 7.5 per cent curry leaves powder which exhibited a high content of β – carotene i.e. 7185.89 µg which initially was 159.18 µg in the control sample, prepared with semolina alone [32]. Thus incorporation of dried green leafy vegetable can prove to be an effective method for enhancing vitamin A content in the diet.

In vitro nutrient digestibility

The data on the *in vitro* protein and carbohydrate digestibility has been presented in Table 6. *In vitro* carbohydrate and protein digestibility was found to be 55 per cent and 63 per cent respectively in the raw Nutrient Dense Ingredient Mix (NDIM). Its cooked counterpart was found to have 69 per cent of *in vitro* carbohydrate digestibility and 72 per cent of *in vitro* protein digestibility. Srivastava and co-workers (2014) reported that *in vitro* protein digestibility of the cooked durum semolina *upma* (control) was 81.94 per cent which highly increased to 91.73 per cent in the cooked multigrain semolina blend (MSB). In case of starch digestibility a decrease was observed from the cooked control (100% durum semolina) to the treated *upma* sample i.e. from 64 per cent to 51 per cent which was due to the lowered quantity of carbohydrates in the MSB *upma* as it consisted of more of the chickpeas than the carbohydrate dense semolina (50% durum semolina) [33].

Anti-nutritional factors

Phytin Phosphorus content (Table 6) of raw NDIM was found to be 152mg whereas it reduced to 97mg after cooking. Similarly, a decrease in the oxalate content after cooking of the mixture was observed i.e. from 69 mg in raw NDIM to 38.92 mg in the cooked NDIM. Phytates in food form insoluble complexes with proteins and hence cause a detrimental effect by reducing the protein and amino acid availability [34]. Utilization of techniques such as roasting on cereals, pulses and oilseeds has been reported to lessen the toxic effects and reduce the content of anti-nutrients or such as polyphenols, phytates, trypsin inhibitor, glycosides, alkaloids and saponins and also increase the shelf life of food commodity [35].

Shelf life of the developed Nutrient Dense Ingredient Mix (NDIM)

Moisture Content

Table 7 delineates the effect of packaging materials and storage on the moisture content of Nutrient Dense Ingredient Mix (NDIM). Different packaging materials were found to have a definite effect on the moisture content of the mix. Mean moisture content of mixture, stored in zip lock pouches (ZP) (6.45%) was found to be higher after a storage period of 30 days than the other two packaging materials, though the difference was not significant. However, packaging remarkably affected the moisture content of mix as the mean moisture content recorded for ZP packaging material (8.77%) was significantly higher than that observed for the PC (8.32%) and GJ (8.08%) materials after a storage period of 120 days. Sharma (2016) observed an increase in the moisture content of extrudates stored in two packaging materials i.e. Aluminium laminate (AL) and Ziploc (ZL) [36]. Nagi et al. (2012) stated that the gain in moisture content can be attributed to the hygroscopic nature of the dried product, the storage environment including temperature, relative humidity as well as the nature of the packaging material [37].

Table 7 Changes in moisture (%); free fatty acid value (FFA, % oleic acid); peroxide value (PV, meq/kg fat) of NDIM on storage

Storage period (in days)	**Parameter**								
	Moisture content (%)			**Free Fatty Acid Value (% Oleic Acid)**			**Peroxide Value (meq/kg fat)**		
	Packaging materials								
	ZP	PC	GJ	ZP	PC	GJ	ZP	PC	GJ
0	5.57 a ± 0.16^{a}	5.57± 0.16^{a}	5.57± 0.16^{a}	0.34 ± 0.02^{a}	0.34± 0.02^{a}	0.34± 0.02^{a}	2.37± 0.11^{a}	2.37± 0.11^{a}	2.37± 0.11^{a}
30	6.45± 0.07^{a}	6.24± 0.19^{a}	6.03± 0.22^{a}	0.44± 0.02^{a}	0.36± 0.02^{a}	0.36± 0.09^{a}	2.66± 0.12^{a}	2.95± 0.45^{a}	2.45± 0.12^{a}
60	6.63± 0.04^{a}	6.80± 0.17^{a}	6.44± 0.28^{a}	0.47± 0.02^{b}	0.40± 0.03^{a}	0.39± 0.02^{a}	4.4± 0.36^{ab}	4.61± 0.14^{b}	3.87± 0.23^{a}
90	7.66± 0.07^{a}	7.61± 0.29^{a}	7.57± 0.24^{a}	0.55± 0.04^{b}	0.49± 0.06^{ab}	0.43± 0.04^{a}	6.49± 0.29^{b}	6.55± 0.33^{b}	5.35± 0.27^{a}
120	8.77± 0.16^{b}	8.32± 0.25^{a}	8.08± 0.13^{a}	0.65± 0.04^{b}	0.58± 0.04^{b}	0.49± 0.04^{a}	8.87± 0.02^{b}	8.2± 0.30^{a}	8.03± 0.12^{a}

Values are expressed as Mean ± SD.
Mean values followed with different superscript(s) within a column are significantly different ($p< 0.05$) using Tukey's test.
ZP- Zip lock pouch; PC- Plastic container; GJ- Glass container

Free fatty acid content (as % oleic acid)

Free fatty acid content (FFA) of Nutrient Dense Ingredient Mix (NDIM) is presented in Table 7. The mixture stored in zip lock pouches (ZP) had higher values for free fatty acids (0.44%) followed by mixture in the plastic containers (PC) (0.36%) and then glass jars (GJ) (0.36%) of evaluation after a storage period of 30 days. However, the difference after a storage period of 30 days was not significant among the three packaging materials. ZP packed NDIM showed a significantly higher value for the mean free fatty acid content (0.65%), while NDIM packed in PC (0.58%), GJ (0.49%) were less in free fatty acids content after a storage period of 120 days. Free fatty acid content found in the ZP mix and PC mix was significantly higher ($p< 0.05$) from the mix in GJ. This result might be attributed to the sturdy air tight capacity of the glass jar (GJ). A noteworthy increase in per cent free fatty acid (as oleic acid %) content was recorded with lengthening of the storage period. It is an established fact that when FFA per cent >1 per cent in fried oil, the product is not fit for consumption [38]. Kumar et al. (2015) found that free fatty acid values increased from 0.44 to 1.28 per cent and 0.44 to 1.07 per cent oleic acids in samples of instant wheat sooji halwa mix packed in polypropylene (PP) and metallised polyester (MP) packaging materials respectively. It was reported that the increase occurred due to the breakage of long chain fatty acids into individual moieties over the period of time [39]. After 6 months of storage of soy fortified instant *sooji upma* mix at ambient conditions, free fatty acids increased from 0.38 to 0.59 per cent oleic acid [28]. The delayed increase in the FFA (% oleic acid) can be attributed to the inclusion of citric acid in the mix in order to increase its shelf life whereas the NDIM developed in the present study was free from any such additive.

Peroxide value

Table 7 depicts the effect of packaging materials ZP, PC, GJ and storage on the peroxide value (PV) of the Nutrient Dense Ingredient Mix (NDIM). Different packaging materials were found to have a significant effect on the peroxide value of the mix right after a storage period of 60 days. It may be observed that the rate of autoxidation as measured by the changes in PV were significantly higher in samples packed in ZP (6.49 meq/kg fat) as compared to those packed in PC (6.55 meq/kg) and GJ (5.35 meq/kg) after a storage period of 90 days. After a storage period of 120 days, mixture stored in the ZP exhibited a significantly higher amount of PV i.e. 8.87 meq/kg whereas PC showed 8.2 meq/kg and GJ showed 8.03 meq/kg of PV which was non-significantly different ($p< 0.05$). The values for PV, in case of all the three packaging materials i.e. ZP, PC and GJ were under permissible limits only as a general regulation states that PV should not be above 10±20 meq/kg fat to avoid development of rancid flavor [40]. The overall increase in PV was lower than that mentioned by Yadav and Sharma (2008) in which PV of soy fortified instant *sooji upma* mix increased from 6.7 to 22.3 meq/kg fat after 6 months [28]. The possible reason could be due to the presence of good amount of polyphenolic compounds in PMS as compared to wheat semolina which worked as antioxidants.

Microbial load

Nutrient Dense Ingredient Mix (NDIM) were packed in polyethylene zip lock pouches (ZP), plastic containers (PC), glass jars (GJ) and stored for 4 months. These samples were assessed for bacterial growth (cfu/g x 10^2) at a regular interval of one month (**Figure 4**). No total bacterial count was reported for the first month. After that a little growth was observed which was possibly due to increase in moisture during storage. Mean values for total bacterial count of the three packaging materials were significantly different from each other right from after a storage period of 90 days. However even up till the fourth month bacterial count was within permissible limits as per FSSAI (2012) i.e. less than 10000 per gram in all packaging material after a storage period of 120 days [41]. On the basis of these findings, it could be contended that the product was safe to consume due to the pre-treatments employed and proper hygienic considerations during preparation of NDIM. Similarly, Anitha and Rajyalakshmi (2014) checked for the shelf life of rice semolina *upma* mix where the total viable bacterial count showed no significant difference during 0–30 days however significant ($p<0.05$) increase on 60–90 days of storage was observed [42]. This decrease in bacterial count up to 60 days of storage was attributed to the lower water activity and initial adaption of microorganisms to the new food media whereas the increase after 60 days was assigned to increase in water activity as well as the growth of microorganisms after adjusting with the food medium [43].

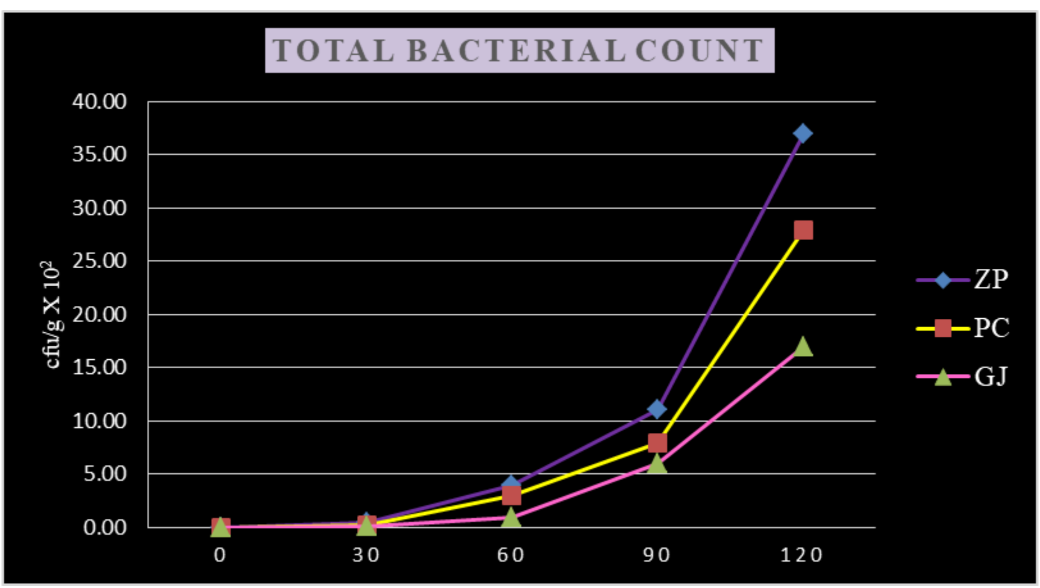

Figure 4 Effect of packaging material and storage on total bacterial count of Nutrient Dense Ingredient Mix (per 100g)

Organoleptic evaluation

The data regarding effect of packaging material and storage period on organoleptic attributes has been presented in **Figure 5**. The overall acceptability of NDIM stored in ZP at 0, 30, 60, 90 and 120 days was 8.0, 7.85, 7.55, 7.24 and 6.81 respectively while, the overall acceptability scores of PC and GJ ranged from 8.16 to 7.17 and 8.25 to 7.39

respectively. GJ exhibited the highest score for overall acceptability after a storage period of 120 days which was significantly different ($p < 0.05$) from the other two, the score was followed by PC (7.17) and the lowest score was secured by ZP (6.81). The decrease in overall acceptability of Zip lock pouches as well as Plastic containers was mainly due to a low score received for their flavor and taste which may be attributed to the presence of pearl millet being a susceptible cause of the same. Yadav and Sharma (2008) reported that organoleptic scores for all sensory responses decreased as storage period increased for the soy fortified instant *sooji upma* mix, however, scores were still in acceptable range even after 6 months of storage [28].

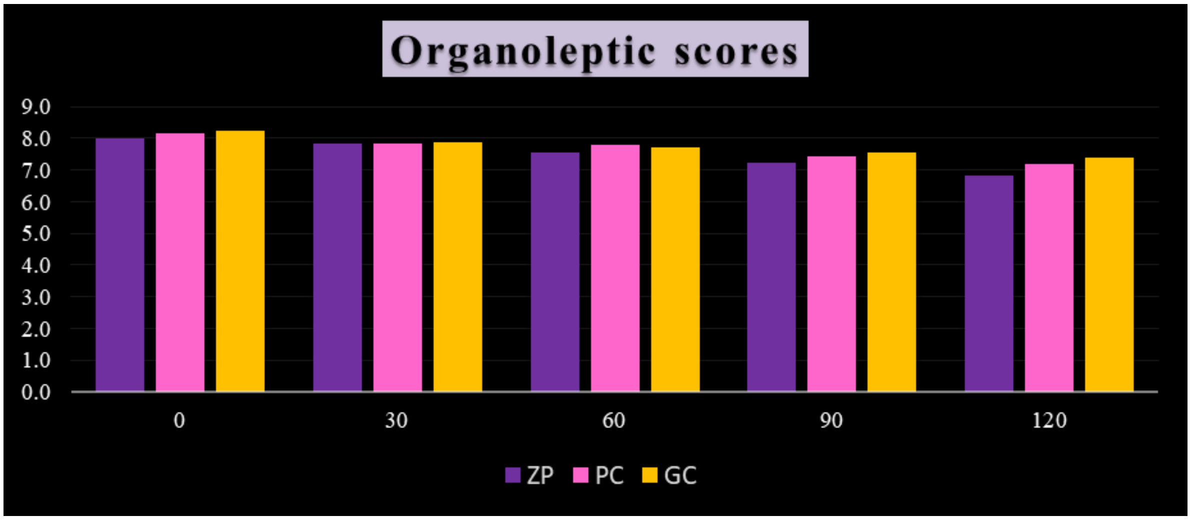

Figure 5 Effect of packaging material and storage on overall acceptability of Nutrient Dense Ingredient Mix (ZP- Zip lock pouch; PC- Plastic container; GJ- Glass container)

Conclusion

Nutrient Dense Ingredient Mix (NDIM) prepared with roasted semolina, whole green gram, pearl millets, peanuts, dried fenugreek leaves, after reconstitution with 100ml boiling water was the best combination organoleptically. The formulated NDIM can be consumed on a daily basis as a nutritious meal or snack at any time of the day with minimal efforts and time for cooking so as to improve the nutritional profile especially with regard to energy, protein and iron as a serving of 100g cooked NDIM can provide with 437.4 Kcal of energy, 13.58g protein and 3.62mg of iron. As raw NDIM can be stored well upto 3 months in an air tight glass jar under ambient conditions hence it can be retrieved that a good packaging material with better barrier properties can improve the shelf life of the product considerably, by retaining the sensory attributes of the products. The product also had an advantage of clean labels as it did not contain any preservatives, additives, anti-caking agents, taste enhancers like those present in the market brands.

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