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Enhancing Pearl Millet based Traditional Foods with various Leaf Powders

By

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Abstract

Six Pearl Millet (variety: HHB 311) based value added traditional food products namely Ladoo, Sev, Matar, Chapatti, Panjiri and Dalia were developed by incorporating Amaranth, Moringa and Bathua leaves powder. These traditional food products were prepared using leaf powders at different levels i.e. 5%, 10%, 15% and 20%. Control samples were also prepared without incorporating the leaf powder. Organoleptic evaluation was done for the developed products and it has been observed that most of the developed products were found to be highly acceptable at 10-20% level of incorporation of leaves powder. The developed value added food products were analysed for proximate composition i.e. moisture, crude protein, crude fat, ash content, crude fiber and carbohydrate content by standard protocols (AOAC, 2010). The crude protein content ranged from 8.06 to 18.98g/100g, maximum was found in Type-III bathua Sev. The crude protein, ash and crude fiber content was significantly increased in developed products with increase in level of supplementation. The calcium, iron and zinc content for all the value added products using three leaves ranged from 140.54 to 534.34 mg/100g, 6.60 to 10.90 mg/100g and 3.35 to 5.88 mg/100g respectively. The available iron and calcium content was found to be higher in supplemented food products as compared to their control products. This study shown a potential use of inexpensive and easily available amaranth, bathua, moringa leaves and pearl millet in development of various value added food products. It is highly recommended that these products can be used for improvement in human health and may improve nutritional status of the community.

Keywords: *pearl millet, bathua, moringa, amaranth leaves, product development, sensory evaluation, nutritional estimation.*

1. INTRODUCTION

Traditional food products persist considerable ethnic and nutritional value, often symbolizing generations of culinary wisdom passed down through families and communities. In recent years, there has been a resurgence of interest in these traditional foods due to their potential health benefits and unique flavor profiles[1]. Among these, pearl millet, a staple crop in many regions of the world, has garnered attention for its nutritional richness and adaptability in various culinary

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applications. In India, traditional food products play a significant role as they showcase our culture as well as they are nutritious too. Currently, these classical Indian products became the choice of researchers for their studies because of their potential health benefits, different flavours, and various methods by which these flavours can be enhanced. Among these, Pearl millet (*Pennisetum glaucum*) is a prevalent crop variety in arid and semi-arid areas, which are distinguished by scant precipitation and unproductive soils. These conditions are unfavourable to main cereals[2]. In terms of energy, proteins, vitamins, minerals, and nutrient content, pearl millet grains are comparable to or even surpass those of other main cereals. In addition to being high in protein (12g/100 g), carbohydrates (67g/100 g), and lipids (5g/100 g), PM offers 360 Kcal/100g of grain. Minerals such as calcium (42 mg/100 g), phosphorus (242 mg/100 g), and iron (8 mg/100 g) are abundant in it[3]. The protein content of variety HHB-311 is 10.20%, while the fibre and fat content are 2.21% and 7.81%, respectively. The iron, zinc, and calcium contents are 564 mg/kg, 87.79 mg/kg, and 55.05 mg/kg, respectively[4]. Pearl millet flour and processed products can be improved by reducing anti-nutritional factors through various techniques like malting, blanching, parboiling, acid and heat treatments, thus enhancing the nutritional value and storability of the grain[5,6,7].

Pearl millet can be substituted for other major cereals for developing value added food products such as traditional products (*chapatti, panjiri Daliya, Sev, matar and ladoo).* This research aims to improve the nutritional value of these traditional products by adding amaranth, *bathua* and moringa leaves powder which are rich in minerals and vitamins. Amaranth (*Amaranthus viridis* L.), a green leafy vegetable, is rich in protein, minerals, vitamins, and fiber. It is used in traditional medicine by Asian and African tribes. Amaranth leaf powder contains 7.50% moisture, 10.61% ash, 18.11% fiber, 3.02% fat, 32.51%) protein, and 28.24%) carbohydrates[8]. It can be combined with wheat flour to create nutrient-rich goods. Researchers are exploring the use of amaranth leaves and seeds in fortified food items[9]. *Bathua* (*Chenopodium album* L.), a medicinal plant, is an invasive herb found in woods and roadsides[10]. Its leaves contain nutrients like moisture, protein, fat, and carbohydrates. *Bathua* leaves also contain thiamine, niacin, vitamin C, β-carotene, iodine, fluorine, vitamin K, calcium, and phosphorus[11]. Many bioactive compounds have been discovered in its various components, according to phytochemical investigations. Furthermore, vanillin, gallic acid, and protocatechuic acid are abundant in *C.album* fruit extracts, but m-coumaric acid is abundant in leaf extracts[12]. *Moringa oleifera,* a plant native to India, Pakistan, Asia Minor, Africa, and Arabia, is a potent remedy for malnutrition. Its leaves, rich in nutrients, have antitumor, anti-inflammatory, and anti-inflammatory properties. They are also used as stimulants in treating various diseases and are the most consumed part of the plant.

Considering nutritional importance of pearl millet as well as the above leaves, there is scope to develop traditional food products from them with high nutritious value. The prime motive of this study was to explore the formulation and nutritional evaluation of traditional food products (*chapatti, panjiri, Daliya, Sev, matar and ladoo).*) by pearl millet combining all the nutritious leaves mentioned above in various proportions and prepare the wholesome Indian food that fulfil the basic requirements of our body.

2. MATERIAL AND METHODS

2.1. Procurement of raw material

The grains of pearl millet variety (HHB-311) were procured from the Bajra section of Department of Genetics and Plant Breeding, CCS, Haryana Agricultural University, Hisar. Amaranth, *bathua*, moringa leaves and other ingredients were procured from the local market.

2.2. Processing of Pearl Millet

To increase the nutritional value pearl millet, blanching was performed on the grains[13]. At 98^{o}c, water was brought to a simmer in a stainless steel container. After 30 seconds of immersion in scalding water (1:5 seed-to-boiling-water ratio), the grains were dried at 50–60ºC in a hot air oven before being ground into flour. Plastic containers were used to retain the dried flour for further use for product development.

2.3. Preparation of amaranth, *bathua* and moringa leaves powder

In accordance with the following procedure mentioned below in figure 1, the Amaranth, *bathua*, and Moringa leaves were dehydrated using a tray dryer or mechanical dehydrator.

Figure 1: In accordance with the following procedure, the amaranth, *bathua*, and moringa leaves were dehydrated using a tray dryer or mechanical dehydrator.

2.4. Development of different value added traditional food products by using amaranth, *bathua* and moringa leaves powder.

By utilizing the enhanced pearl millet (HHB-311), value-added traditional food products were developed. Powdered amaranth, *bathua*, moringa, leaves were utilised individually at concentrations of 5%, 10%, 15%, and 20% in the product development. Other ingredients were used in various proportions depending on the need of each recipe. As a control, a standard formulation for comparable products containing pearl millet but no leaf powder was utilized. The following products were developed i.e. *Ladoo, Sev, Matar, Chapati, Panjiri,* and *Dalia*.

2.4.1. *Ladoo*

It is a spherical confection comprised of a ball-shaped mélange of sugar, ghee, and flour of various types. It is one of the most loved sweets by Indians. The process of formulation of these nutritious *Ladoo's* is mentioned below in figure 2A and after formulation, *Ladoo's* look like as presented in figure 2B.

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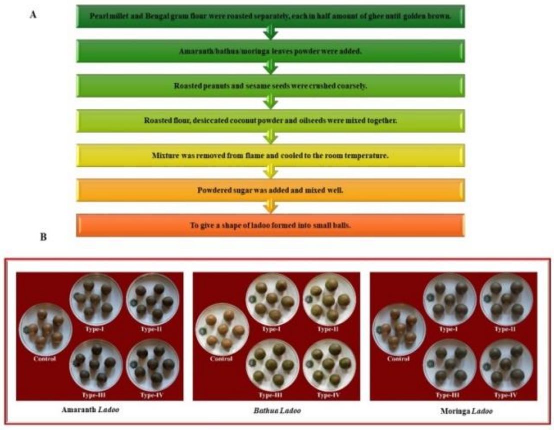

Figure 2: Process of formulation of *Ladoo's* is mentioned in A. Final appearance of *Ladoo's* is presented in B.

2.4.2. *Sev*

Popular in northern India, it is a savoury, crisp, noodles-like substance composed of long, thin filaments of flour that have been deep-fried. In accordance with the recipe's instructions as stated in figure 3A and cooked *sev* will look like figure 3B.

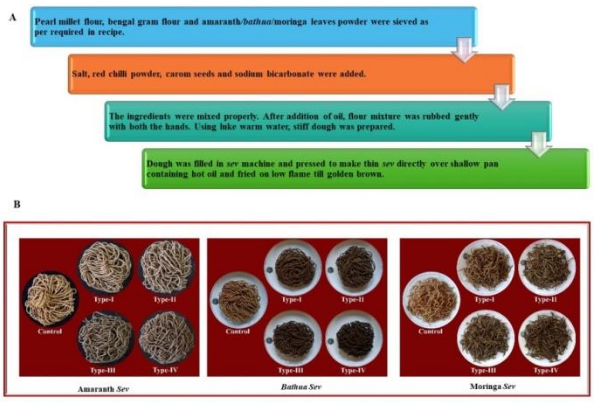

Figure 3: Method of formulation of *Sev* (A). Formulated *sev* with incorporation of nutritious leaves powder (B).

2.4.3. *Matar*

Matar is a savoury, crunchy delicacy that is well-liked in northern India. *Ajwain* and cumin seeds are used to delicately season these ribbon-like segments. In the specified proportions, sieved amaranth/*bathua*/moringa leaf powder, refined flour, and PM flour were combined appropriately. Process of formulation is mentioned figure 4A. *Chapatti* were portioned into small rectangular pieces using a knife and subsequently placed in a shallow pan filled with heated oil. Fry over a medium flame until crisp-tender like figure 4B.

Figure 4: Process of formulation is shown in A whereas result of formulation is presented in B.

2.4.4. *Chapatti*

It is an unleavened, round, flat bread from India that is prepared using a variety of flours and a griddle. The specified quantities of ingredients as mentioned in table were combined in a sieve and thoroughly mixed. With the addition of water and appropriate mixing, a soft dough was formed. To form chapattis, the dough was formed into tiny balls and rolled. Ghee-greased chapattis that were properly prepared and served hot as illustrated in figure 5.

Figure 5: Nutritious *Chapattis* including various leaf powder

2.4.5. *Panjiri*

Panjiri is a sweet from North India that consists of various flours, sugar, and ghee, and is densely infused with herbal gums and preserved fruits. Bengal gram flour and pearl millet were toasted in a small quantity of ghee until they both turned golden brown, separately. Additionally, sesame seeds and peanuts were roasted separately. Powdered amaranth, *bathua*, and moringa leaves were added in the specified amounts. The mixture was cooled after being removed from the conflagration. After that, thoroughly combining ground sugar, sesame seeds, and peanuts, the mixture was served as represented in figure 6.

Figure 6: *Panjiri* prepared by incorporating various leaf powder

2.4.6. *Dalia (salty)*

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It is a thick, sticky porridge prepared from millet grits or cereals and water or milk, which is typically consumed for breakfast and may be sweet or salty. While grits made from PM were boiled, each vegetable was blanched in a separate pan. In a wok, melt ghee before adding blanched vegetables and frying for one minute. Powdered amaranth, *bathua*, and moringa leaves were combined with all the seasonings in a wok containing water in the specified proportions. Grits of boiled PMs were incorporated, continuously stirred, and heated for an additional 2-3 minutes and it will look like figure 7.

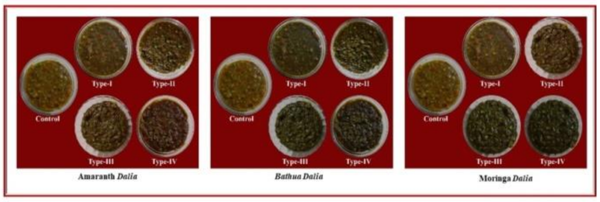

Figure 7: **Dalia** ***prepared by incorporating various leaf powder***

3. SENSORY AND NUTRITIONAL EVALUATION OF DEVELOPED TRADITIONAL FOOD PRODUCTS.

A group of ten evaluators from the Department of Foods & Nutrition, IC COHS, CCSHAU, Hisar conducted an organoleptic evaluation of each of the developed products. A total of thirty individuals comprised the council, which was determined by their willingness, health, and expertise in sensory analysis. Regarding overall acceptability, the mean ratings for each of the following sensory attributes was calculated: colour, appearance, aroma, texture, and flavour. The products with the highest level of acceptability within each category were subjected to analysis regarding their proximate composition, mineral content, and total antioxidant activity.

3.1. Proximate analysis

The food samples which highly acceptable were analysed for their moisture content, crude protein content, crude fat content, crude fiber content, total ash and carbohydrate content by the standard method given by AOAC[14].

3.2. Mineral content estimation

3.2.1. Estimation of calcium

In a 100 mL China dish, 5 mL of diluted digested sample were combined with 10 mL of distilled water. Ten droplets each of 2% NaCN and 5% hydroxylamine hydrochloride solution were added to the diluted sample. Following this, 10–15 droplets of calcon indicator were added to 2.5 mL of 4 N NaOH solution. The colour pink emerged. A blank solution was prepared in a distinct China dish using the identical procedure as the test solution, except substituted with 5 mL of distilled water for the test solution. If a blue colour was not observed in the blank, two to three droplets of EDTA solution were added; this blue blank was utilised to compare the end point of the test solution. In conjunction with the magnetic stirrer, a glass-coated iron needle was inserted into the test solution that was positioned on its surface. Using 0.01 N EDTA, the pink hue of the solution was titrated until it matched the blue hue of the blank[15]. For calculations, the following formula was used:

$$\text{Ca (mg per 100g)} = \frac{\text{mL of EDTA used} \times \text{Normality of EDTA} \times \text{Dilution factor} \times 100}{\text{mL of aliquot taken for titration}}$$

3.2.2. Determination of Iron and Zinc

In a 150 mL conical flask, a two-gram dried and ground sample was taken. 20mL diacid mixture (HNO_3:$HClO_4$: 5:1 v/v) was added to this and kept overnight. It was digested the next day by heating until clear white precipitates settled at the bottom. The crystals were dissolved in double distilled water. Whatman No. 42 filter paper was used to filter the contents. 50mL double distilled water was used to make the filtrate. This acid digested sample was used for the determination of calcium, iron and zinc. Iron and zinc were determined by Atomic Absorption Spectrophotometer AABQ-20[16].

3.2.3. Determination of available minerals

3.2.3.1. Iron

Ionizable iron in the samples was extracted[17]. Free form of iron in the filtrate reacts with α', α'-dipyridyl was determined as described by AOAC[14]. 1 mL of 10% hydroxylamine hydrochloride solution was added to 10 mL of filtrate in a 25 mL volumetric flask. The volume was reduced to 25 mL by adding water, and the contents were thoroughly mixed. The color intensity was measured at 510 nm. To make a standard curve, 10 to 50 mL of iron standard were placed in a 100 mL volumetric flask, 2.0 mL of HCl was added to each, and the volume was increased to 100 mL with water. Blank was also made in the same way. 10 mL of each of these solutions were taken in 25 mL volumetric flask and preceded as described above.

3.2.3.2. Calcium

In a conical flask containing 2 gram of the finely ground sample, 3 mL of distilled water were added to rehydrate it. A volume of 20 mL of pepsin solution (0.1% pepsin in 0.1 N HCl) was introduced into the mixture. Dilute HCl was utilised to modify the pH to 1.5. The contents were incubated for one hour at 37°C in a water bath with agitation. Consequently, a solution of sodium bicarbonate was employed to increase the pH of the solution to 6.8. Following that, the contents were incubated with 2.5 mL of a suspension containing 0.5% pancreatin in 5% bile at 37°C for one hour. The remainder of the volume was reduced to 50 mL by adding distilled water to the remaining substance. The contents were subsequently centrifuged at 5°C for 45 minutes at 50,000 rpm. The collected supernatant was centrifuged at 5°C for 45 minutes at 25,000 rpm[18]. The supernatant was gathered, desiccated in an oven, digested in a diacid solution, and the calcium content was quantified by means of an atomic absorption spectrophotometer.

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4. STATISTICAL ANALYSIS

For statistical analysis, the online applications SPSS and OPSTAT were utilised. The statistical tests utilised were the paired t-test and one-way ANOVA. A one-way ANOVA was utilised to compare the means of value-added food products and basic ingredient organoleptic evaluations.

5. RESULTS AND DISCUSSION

5.1. Sensory evaluation of developed PM based traditional food products:

A group of semi-trained panelists, who were well-versed in the quality of the products, utilized a nine-point hedonic scale to assess the aforementioned attributes of foods formulated with powdered amaranth, *bathua*, and moringa leaves derived from pearl millet flour. The mean scores for organoleptic attributes (including colour, appearance, aroma, texture, taste, and overall acceptability) of pearl millet-based products formulated with value-added and control ingredients (including powdered amaranth, *bathua*, and moringa leaves) are displayed in Table no. 1 and Figure 8.

5.1.1. *Ladoo*

Data for organoleptic scores of *ladoo* is elucidated in table 1: four types of *ladoo* were prepared using PM flour and powdered with amaranth, *bathua*, and moringa leaves. The *ladoos* had varying acceptability scores, with the control *ladoo* having the highest scores. The *ladoos* incorporating these leaves had higher acceptability scores, except for the type incorporating *bathua* leaves powder. The *ladoos* from amaranth and moringa leaves were considered the best. Similarly, *ladoo* prepared by using various leaves powder were also found to be organoleptically acceptable and reduction in score were noticed with increase in amount of cauliflower and turnip leaves powder[19].

5.1.2. *Sev*

The sensory acceptability of the *sev* varied between moderately and very much. The overall acceptability ranged from 6.56-8.12, with the control *sev* having an overall score of 8.78. The *sev's* color, appearance, aroma, texture, and taste were all moderately liked, except for the aroma and texture scores for Type-III *sev*. Moringa leaves powder also had moderately liked scores. *Sev* incorporated with 15 per cent *bathua* leaves powder was found to be highly acceptable among all three types of *sev* developed incorporating selected three leaves powder. *Sev* prepared by using PM flour was also 'liked moderately' for all the sensory characteristics[20, 21].

5.1.3. *Matar*

The mean scores for taste varied, with amaranth *matar* scoring higher than *bathua matar*. Moringa *matar* scored moderately, except for Type-IV, which was slightly liked. Control *matar* had higher acceptability scores in color, appearance, aroma, texture, and taste. All value-added *matar* incorporating these leaves powders fell under the 'liked moderately' category. The scores of all sensory parameters of *matar* decreased with increased level of incorporation of leaves powder. Similarly, in another study, m*atar* developed were found in 'liked very much' and 'liked moderately' category, respectively[20, 22].

5.1.4. *Chapatti*

Chapatti incorporated with amaranth and moringa leaf powder at 20% level was found to be highly acceptable in all sensory attributes. Results of the present study were in close agreement with the results earlier reported in another study where they had developed supplemented *chapatti* using PM flour which lied in the category of 'liked moderately'[22, 23].

5.1.5. *Panjiri*

The study analyzed the organoleptic scores of four types of PM flour-based *panjiri*, which were developed with amaranth, *bathua*, and moringa leaves powder at different levels. All types were found to be organoleptically acceptable. Control *panjiri* had the highest acceptability scores in color, appearance, aroma, texture, taste, and overall acceptability. *Panjiri* with 20% amaranth and *bathua* leaves powder was highly acceptable. The present results were in concordance with the results given in similar study who reported overall acceptability of different supplemented *panjiri* to be in 'liked moderately to liked very much' category[24, 25].

5.1.6. *Dalia*

Data in table 1 and figure 8 indicated that all types of PM flour based *dalia* were found to be organoleptically acceptable.

Table 1: Mean scores of organoleptic acceptability of pearl millet based value added Traditional food products by incorporating amaranth, *bathua* and moringa leaves powder.

Products	Most accepted products	Organoleptic acceptability					
		Color	Appearance	Aroma	Texture	Taste	Overall Acceptability
Ladoo	Control	8.74±0.24	8.71±0.27	8.78±0.19	8.85±0.12	8.83±0.17	8.78±0.06
	ALP (20%)	7.73±0.13	7.66±0.16	7.67±0.23	7.76±0.13	7.59±0.14	7.68±0.05
	BLP (15%)	7.71±0.25	7.83±0.06	7.66±0.11	7.76±0.16	7.78±0.09	7.74±0.12
	MLP (20%)	8.19±0.46	7.34±0.17	8.23±0.46	7.30±0.26	8.28±0.38	7.86±0.37
	Control	8.78±0.16	8.83±0.17	8.83±0.14	8.74±0.25	8.73±0.18	8.78±0.13
	ALP (20%)	7.56±0.09	7.59±0.20	7.75±0.14	7.84±0.09	7.47±0.20	7.64±0.02

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Sev	BLP (15%)	8.48±0.17	8.48±0.55	8.64±0.13	7.96±0.21	7.77±0.22	8.26±0.21
	MLP (15%)	7.72±0.26	7.83±0.06	7.65±0.21	7.78±0.13	7.80±0.10	7.75±0.09
Matar	Control	8.48±0.45	8.84±0.14	8.85±0.10	8.89±0.09	8.87±0.09	8.78±0.12
	ALP (15%)	7.20±0.64	8.61±0.19	7.95±0.19	7.77±0.22	7.77±0.18	7.86±0.15
	BLP (10%)	7.55±0.29	7.55±0.20	7.63±0.24	7.67±0.22	7.71±0.19	7.61±0.12
	MLP (15%)	7.99±0.47	7.64±0.17	7.96±0.19	7.77±0.22	7.78±0.23	7.84±0.12
Chapati	Control	8.75±0.05	8.79±0.05	8.86±0.04	8.78±0.04	8.73±0.06	8.78±0.09
	ALP (20%)	7.56±0.06	7.58±0.05	7.87±0.07	7.92±0.04	7.47±0.06	7.68±0.03
	BLP (20%)	8.13±0.13	7.80±0.04	7.87±0.12	7.78±0.05	8.48±0.13	8.01±0.03
	MLP (15%)	7.69±0.04	7.96±0.03	7.68±0.02	7.69±0.05	7.70±0.03	7.74±0.02
Panjiri	Control	8.70±0.23	8.74±0.28	8.77±0.10	8.85±0.12	8.82±0.17	8.77±0.19
	ALP (20%)	7.71±0.16	7.63±0.17	7.63±0.14	7.73±0.13	7.59±0.20	7.66±0.23
	BLP (20%)	7.53±0.19	7.57±0.18	7.77±0.21	7.84±0.19	7.49±0.23	7.64±0.23
	MLP (15%)	7.63±0.14	7.97±0.11	7.62±0.24	7.60±0.27	7.78±0.18	7.72±0.25
Dalia	Control	8.62±0.09	8.81±0.02	8.75±0.05	8.71±0.04	8.74±0.03	8.72±0.02
	ALP (15%)	7.71±0.08	7.83±0.02	7.65±0.04	7.78±0.04	7.79±0.03	7.75±0.02
	BLP (15%)	8.18±0.14	7.74±0.05	7.96±0.03	7.77±0.07	7.78±0.05	7.88±0.02
	MLP (10%)	7.57±0.08	7.63±0.06	7.35±0.05	7.38±0.05	7.55±0.05	7.49±0.02

Values are mean ± SE of three independent determinants
ALP- Amaranth leaves powder BLP- *Bathua* leaves powder
MLP- Moringa leaves powder

The study found that Type-I, Type-II, Type-III, and Type-IV *dalia* supplemented with amaranth, *bathua*, and moringa leaves powder were 'liked moderately'. Control *dalia* had the highest mean acceptabilty scores for color, appearance, aroma, texture, taste, and overall acceptability.

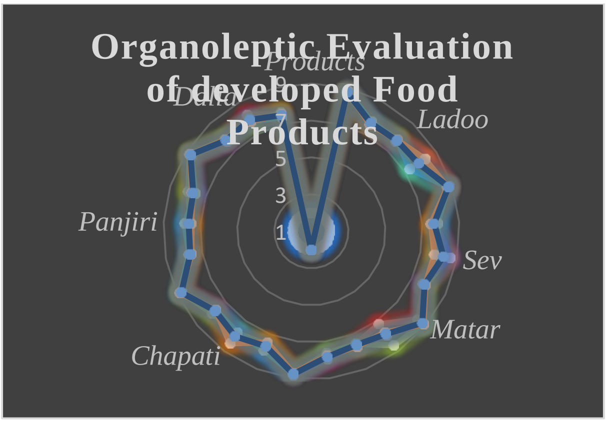

Figure 8: Sensory evaluation of developed Food Products

Type-III *dalia* with amaranth and *bathua* leaves powder were highly acceptable, while Type-II *dalia* with moringa leaves powder was the most acceptable. Results of the present study were concordant with the results presented in similar study who developed *dalia* using PM flour by incorporating *jamun* seeds powder and reported overall acceptability in range of 'liked slightly' to 'liked moderately' category[21].

5.2. Nutritional evaluation of developed value-added traditional products.

The study analysed the nutrient composition of value-added traditional products, focusing on products with a high percentage of leaf powder, including amaranth, *bathua*, and moringa leaves powder are as follows table 2 and 3.

5.2.1. *Ladoo*

According to the findings of proximate analysis (Table 2), the moisture content of the *ladoo* that was developed varied between 2.50 and 3.84 g/100g. The study analyzed the dry matter contents of various *ladoos*, including control, amaranth, 15% *Bathua* powder, moringa leaf powder, and PM. The control *ladoo* had higher crude protein, fat, ash, total carbohydrates, and fiber contents. Where in an another study, the *ladoo* developed with different flour, amount of protein ranged from 14.33 to 15.55 g/100g which was almost similar to the present study *Ladoos* with 15% *Bathua* powder, moringa leaf powder, and 15% ALP had higher total mineral content, iron, zinc, and calcium content[13]. The MLP *ladoo* had higher total iron, zinc, and calcium content. Total iron, zinc, calcium in control (pearl millet based *ladoo*) was found to be 5.89, 4.23 and 125.42 mg/100g, respectively whereas, available iron and calcium content were recorded as 1.57 and 36.79 mg/100g, respectively. *Ladoo* developed with incorporation of different proportions of cauliflower, turnip

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and *mahua* leaves in *ladoo* improved the iron (8.06 to 26.23%) and calcium (43.98 to 369.72%) content significantly than control *ladoo*[26,19].

5.2.2. *Sev*

The moisture content of developed *sev* ranged from 1.10 to 1.68 g/100g. Crude protein, crude fat, ash, crude fibre and total carbohydrates content of control *sev* was noticed as 15.18, 27.16, 2.14, 2.34 and 53.18 g/100g, respectively, whereas that of *sev* incorporated with amaranth leaves powder were found to be 17.14, 25.45, 4.10, 3.87 and 49.44 g/100g, respectively. Proximate composition revealed that BLP *sev* (15%) contained 18.98, 25.17, 3.43, 2.95 and 49.47 g/100g of crude protein, crude fat, ash, crude fibre and total carbohydrates content, respectively and that of moringa powder *sev* was observed to be 16.08, 24.26, 3.55, 3.50 and 52.61 g/100g, respectively, on dry matter basis. Control *sev*, was found to have total iron; 6.23mg/100g, zinc, 3.43 mg/100g, calcium, 34.68mg/100g, available iron, 1.13 mg/100g and available calcium, 11.30 mg/100g. Total iron, zinc, calcium in ALP *sev* was observed to be 7.30, 3.79 and 484.59 mg/100g, respectively and available iron and calcium content was 1.52 and 181.62 mg/100g, respectively. *Bathua* leaves powder incorporated *sev* contained 8.31, 3.55 and 269.63 mg/100g of total iron, zinc and calcium content, respectively whereas available iron and calcium was 2.33 and 94.20 mg/100g, respectively. In *sev* with 15 per cent moringa leaves powder, total iron, zinc, and calcium was noticed as 8.80, 3.75 and 329.32 mg/100g, respectively and available iron and calcium was recorded to be 2.48 and 117.03 mg/100g, respectively. In the similar way, the proximate composition of developed supplemented products like *sev* and *mathi* were found to be significantly higher in protein, fat, ash and fibre content[27].

5.2.3. *Matar*

The nutritional analysis shown in table 2 and 3, that *Matar* with amaranth leaves powder, *bathua* leaves powder, moringa leaves, and *bathua* leaves powder had higher crude protein, fat, ash, fibre, and total carbohydrates content, while the moisture content ranged from 2.14 to 4.14 g/100g.

Table 2: Proximate composition of developed value added food products

Products	Most accepted products	Proximate composition (g/100g)					
		Moisture #	Crude protein	Crude fat	Ash	Crude fibre	Total carbohydrates
Ladoo	Control	3.42±0.10	11.70±0.10	32.70±0.37	1.52±0.04	1.91±0.02	52.17±0.37
	ALP (20%)	3.48±0.06	14.27±0.04	34.35±0.01	3.53±0.04	3.62±0.03	44.23±0.33
	BLP (15%)	2.50±0.23	15.59±0.15	32.38±0.04	2.61±0.03	2.90±0.02	46.52±0.70
	MLP (20%)	3.84±0.06	14.37±0.51	34.14±0.57	3.01±0.02	4.43±0.03	44.05±0.31
Sev	Control	1.29±0.14	15.18±0.12	27.16±0.09	2.14±0.09	2.34±0.01	53.18±0.07
	ALP (20%)	1.10±0.08	17.14±0.02	25.45±0.11	4.10±0.01	3.87±0.01	49.44±0.32
	BLP (15%)	1.48±0.05	18.98±0.05	25.17±0.10	3.43±0.16	2.95±0.01	49.47±0.26
	MLP (15%)	1.68±0.35	16.08±0.03	24.26±0.13	3.55±0.32	3.50±0.12	52.61±0.34
Matar	Control	4.14±0.10	10.42±0.06	26.70±0.08	1.85±0.02	1.36±0.08	59.67±0.55
	ALP (15%)	3.46±0.02	12.60±0.17	24.10±0.12	3.59±0.04	3.23±0.14	56.48±0.29
	BLP (10%)	2.14±0.01	10.96±0.12	23.08±0.39	2.42±0.13	4.50±0.05	59.04±0.29
	MLP (15%)	2.35±0.07	11.48±0.15	24.77±0.71	2.25±0.07	2.70±0.11	58.80±0.65
Chapati	Control	27.89±0.15	10.03±0.26	7.03±0.09	2.65±0.03	2.31±0.01	77.98±0.56
	ALP (20%)	25.52±0.28	12.32±0.05	6.24±0.01	4.22±0.12	4.18±0.03	73.04±0.58
	BLP (20%)	25.02±0.05	13.73±0.03	6.08±0.05	5.40±0.02	3.13±0.03	71.66±0.15
	MLP (15%)	25.18±0.10	12.20±0.04	6.20±0.02	3.34±0.01	3.49±0.01	74.77±0.11
Panjiri	Control	2.35±0.21	11.70±0.26	22.58±0.07	1.54±0.05	3.48±0.01	60.70±0.28
	ALP (20%)	1.22±0.16	15.14±0.23	20.39±0.61	3.41±0.04	4.18±0.04	56.88±0.21
	BLP (20%)	1.19±0.02	15.33±0.05	19.86±0.12	2.67±0.15	2.85±0.07	59.29±0.44

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	MLP (15%)	1.13±0.02	13.82±0.03	21.69±0.01	1.83±0.02	3.29±0.10	59.37±0.12
Dalia	Control	62.75±0.18	12.62±0.15	19.26±0.02	3.01±0.04	2.96±0.07	62.15±0.01
	ALP (15%)	60.27±0.07	14.84±0.04	22.17±0.03	5.26±0.03	4.11±0.06	53.62±0.08
	BLP (15%)	60.34±0.44	15.50±0.10	20.10±0.04	4.86±0.02	3.46±0.01	55.88±0.16
	MLP (10%)	60.16±0.02	14.15±0.07	21.27±0.01	3.80±0.15	4.21±0.01	56.57±0.02

Values are mean ± SE of three independent determinants
#As is basis
ALP- Amaranth leaves powder
BLP- *Bathua* leaves powder
MLP- Moringa leaves powder

The study found that control *matar* had a total iron, zinc, and calcium content of 6.56, 3.86, and 44.39 mg/100g, respectively. *Matar* supplemented with ALP (15%) contained 8.00, 3.94, and 359.54 mg/100g of these minerals. *Matar* incorporated with 10% BLP had 6.73, 3.93, and 162.39 mg/100g, respectively. Results indicated that total antioxidant activity in control *matar* was found to be 0.53 mg/g, whereas that of ALP, BLP and MLP *matar* was noticed as 0.98, 0.85 and 1.15 mg/g, respectively. Results indicated that total antioxidant activity in control *matar* was found to be 0.53 mg/g, whereas that of ALP, BLP and MLP *matar* was noticed as 0.98, 0.85 and 1.15 mg/g, respectively. The present results for fat in control *matar* were slightly lower than the content reported in another study whereas, ash content of *matar* followed the content reported by Singh (2003) and Savita (2018)[20,22].

5.2.4. *Chapatti*

The study found that the moisture content of developed chapatti varied from 25.02 to 27.89 g/100g. The crude protein, fat, ash, fibre, and total carbohydrates content varied among different types of chapattis, with the highest content found in moringa leaves-supplemented *chapatti*. Similarly, proximate constituents was found to be enhanced in supplemented *khakhra*, *namakpara*, *sev*, *chapatti* with different millet and leaves powder[27,28,29]. The study analyzed the iron, zinc, and calcium content of PM flour-based *chapatti*, *bathua* leaves powder-incorporated chapatti, and a mixture of PM flour and *bathua* leaves powder. The results showed that the control chapatti contained 6.22, 3.62, and 38.29 mg/100g of total iron, zinc, and calcium, respectively, while the ALP *chapatti* had 8.52, 4.44, and 485.53 mg/100g while in a similar study, it has been found that the addition of dehydrated curry leaves powder significantly improved iron (4.02-9.39 mg/100 g) and calcium (103.34-219.30 mg/100 g) levels[30].

5.2.5. *Panjiri*

The results of the study (Table 2) showed that moisture content of all types of developed *panjiri* ranged from 1.13 to 2.35 g/100g. In the current study it has been found that control *panjiri* had varying crude protein, fat, ash, fibre, and total carbohydrates content. ALP-supplemented panjiri had higher protein, fat, ash, fibre, and total carbohydrates content as shown in the table. Whereas crude protein content in present study was in line with the values reported in a similar study[31]. Lower results for ash and crude fibre content was earlier reported in another sudy[31] and also the results of present study were slightly higher than the findings earlier quoted in similar study who developed PM based *panjiri* by supplementing carrot and sesame seeds powder. The study found that control *panjiri* had lower mineral content, while ALP *panjiri* had higher content[24,25].

The available iron and calcium content varied among *panjiri*. Available iron and calcium content in *bathua* powder *panjiri* was 1.92 and 83.36 mg/100g, respectively and that of MLP *panjiri* was observed to be 3.03 and 117.02 mg/100g, respectively. *Panjiri* incorporated with 20% BLP had higher content, while *bathua* powder *panjiri* had higher content.

Table 3: Total and available mineral composition of developed value added food products by incorporating amaranth, *bathua* and moringa leaves powder.

Products	Most accepted products	Total minerals (mg/100g)			Available minerals (mg/100g)	
		Iron	Zinc	Calcium	Iron	Calcium
Ladoo	Control	5.89±0.11	4.23±0.13	125.42±2.21	1.57±0.01	36.79±0.89
	ALP (20%)	9.05±0.25	4.37±0.11	534.34±1.72	3.88±0.35	176.79±1.30
	BLP (15%)	9.55±0.29	4.91±0.05	306.63±1.96	1.86±0.14	102.54±1.31
	MLP (20%)	10.90±0.45	5.35±0.26	493.64±0.29	1.98±0.21	173.63±1.26
	Control	6.23±0.08	3.43±0.18	34.68±0.86	1.13±0.02	11.30±0.02
	ALP (20%)	7.30±0.18	3.79±0.20	484.59±1.61	1.52±0.30	181.62±1.33

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Sev	BLP (15%)	8.31±0.10	3.55±0.07	269.63±1.58	2.33±0.02	94.20±1.41
	MLP (15%)	8.80±0.14	3.75±0.11	329.32±1.73	2.48±0.13	117.03±1.11
Matar	Control	6.56±0.28	3.86±0.09	44.39±1.67	0.83±0.03	14.50±0.47
	ALP (15%)	8.00±0.13	3.94±0.04	359.54±1.80	1.12±0.05	122.65±1.33
	BLP (10%)	6.73±0.13	3.93±0.14	162.39±1.88	1.42±0.03	55.97±1.04
	MLP (15%)	8.12±0.14	4.55±0.03	326.05±1.81	1.82±0.03	120.09±1.07
Chapati	Control	6.22±0.10	3.62±0.08	38.29±1.70	1.40±0.01	12.23±0.34
	ALP (20%)	8.52±0.20	4.44±0.20	485.53±1.74	4.02±0.34	163.67±1.60
	BLP (20%)	9.36±0.11	4.35±0.16	218.65±1.35	3.14±0.35	73.90±0.99
	MLP (15%)	9.03±0.7	5.88±0.36	443.52±2.69	2.20±0.20	163.19±1.20
Panjiri	Control	5.59±0.15	3.80±0.10	43.23±1.98	0.73±0.02	11.15±0.21
	ALP (20%)	7.21±0.11	3.98±0.21	474.88±2.59	1.21±0.05	155.43±1.04
	BLP (20%)	7.84±0.08	3.98±0.15	273.32±1.56	1.92±0.04	83.36±0.88
	MLP (15%)	8.28±0.14	4.36±0.17	313.71±0.74	3.03±0.01	117.02±1.03
Dalia	Control	6.77±0.16	3.64±00.05	73.59±0.88	1.62±0.02	19.94±0.14
	ALP (15%)	9.66±0.24	4.01±0.04	407.33±2.89	3.42±0.05	146.31±1.67
	BLP (15%)	10.63±0.20	3.92±0.15	251.15±1.94	2.38±0.02	85.46±1.08
	MLP (10%)	7.38±0.14	4.37±0.11	270.68±2.21	2.30±0.06	93.71±1.38

Values are mean ± SE of three independent determinants
ALP- Amaranth leaves powder
BLP- *Bathua* leaves powder
MLP- Moringa leaves powder

Total minerals content in *panjiri* in present study were found to be resembling to the earlier studies[17, 25].

5.2.6. *Dalia*

Dalia with 15% ALP and 15% BLP contained different crude protein, fat, ash, fibre, and total carbohydrates content. *Dalia* supplemented with 10% moringa leaves powder had similar content. Present values for crude protein and crude fibre in supplemented *dalia* was found like the values presented in similar study[32,13,33]. In the present study it has been found that control *dalia* had a total mineral content of 6.77, 3.64, and 73.59 mg/100g, while ALP (15%) *dalia* had 9.66, 4.01, and 407.33 mg/100g. PM-based *dalia* had 1.62 and 19.94 mg/100g, while *dalia* supplemented with 15% BLP had 10.63, 3.92, and 251.15 mg/100g, and *dalia* incorporated with MLP had 7.38, 4.37, and 270.68 mg/100g.

6. CONCLUSION

The present study successfully formulated and nutritionally evaluated traditional food products enriched with pearl millet and the nutrient-dense powders of moringa, amaranth, and *bathua* leaves. The incorporation of these leafy powders significantly enhanced the nutritional profile of the products, particularly in terms of protein, fiber, vitamins, and minerals, without compromising sensory acceptability. These findings highlight the potential of utilizing underutilized crops and traditional ingredients to develop cost-effective, health-promoting food products. Such innovations can play a vital role in combating malnutrition and promoting sustainable food systems.

7. CONFLICT OF INTERESTS

The authors declare that there is no competing interest.

8. REFERENCES

1. Ghosh S., Meyer-Rochow V. B., Jung C. Embracing Tradition: The Vital Role of Traditional Foods in Achieving Nutrition Security. *Foods*. 2023; 12(23): 4220. DOI: https://doi.org/10.3390/foods12234220
2. Sibanda F., Jideani V. A., Obilana, A. O. Nutritional, biochemical, and functional properties of pearl millet and moringa oleifera leaf powder composite meal powders. *Foods*. 2024; 13(5): 743. DOI: https://doi.org/10.3390/foods13050743
3. Malik S. Pearl Millet- Nutritional value and medicinal uses. *International Journal of Advance Research and Innovative Ideas in Education*. 2015; 1(3):2395-4396. DOI: https://doi.org/10.1017/s0003598x00061378
4. Samtiya M., Chandratre G. A., Dhewa T., Badgujar P.C., Sirohi R., Kumar A., Kumar A. A comparative study on comprehensive nutritional profiling of indigenous non-biofortified and bio-fortified

*Corresponding Author: **Manohar Lal**

varieties and biofortified hybrids of pearl millets. *Journal of Food Science and Technology*. 2022; 60(3): 1065-1076. DOI: https://doi.org/10.1007/s13197-022-05452-x

5. Khairwal I. S., Sehgal S., Rai K. N., Kawatra A. Diversified uses of Pearl Millet, All India Coordinated Pearl Millet Improvement Project (ICMR), Mandor, Jodhpur. 2004.
6. Singh N. B., Saini R. S. Products, diversification, marketing and price discovery of pearl millet in India. Documentation, National Rainfed Area Authority, Todapur Village, Pusa. 2012.
7. Legesse E. Effect of processing on quality characteristics of pearl millet (*pennisetum glaucum*) based value added products, MSc thesis. 2013.
8. Beswa D., Dlamini N. R., Siwela M., Amonsou E. O., Kolanisi U. Effect of Amaranth addition on the nutritional composition and consumer acceptability of extruded provitamin A-biofortified maize snacks. *Food Science and Technology*. 2016; 36: 30-39. DOI: https://doi.org/10.1590/1678-457X.6813
9. Qumbisa N. D., Ngobese N., Kolanisi U. Potential of using amaranthus leaves to fortify instant noodles in the South African context: A review. *African Journal of Food, Agriculture, Nutrition and Development*. 2020; 20(4): 16099-16111. DOI: https://doi.org/10.18697/ajfand.92.18690
10. Paniagua-Zambrana N. Y., Bussmann R. W., Echeverría J., Romero, C. *Chenopodium album* L. *Chenopodium quinoa* Wild. *Chenopodium hircinum Schrad*. *Chenopodiastrum murale* (L.) S. Fuentes, Uotila and Borsch Amaranthaceae. *Ethnobotany of the Andes*: 2020; 1-8.
11. Kaur N., Kaur G. Effect of processing on nutritional and antinutritional composition of *bathua* (*Chenopodium album*) leaves. *Journal of Applied and Natural Science*. 2018; 10(4): 11491155. DOI: https://doi.org/10.31018/jans.v10i4.1856
12. Laghari A. H., Memon S., Nelofar A., Khan K. M., Yasmin A. Determination of free phenolic acids and antioxidant activity of methanolic extracts obtained from fruits and leaves of *Chenopodium album*. *Journal of Food Chemistry*. 2011; 126(4): 1850-1855. DOI: https://doi.org/10.1016/j.foodchem.2010.11.165
13. Johari A. Development of pearl millet and rice based gluten free food products. M.Sc. Thesis, CCSHAU, Hisar, India. 2013.
14. AOAC Official Methods of Analysis of Association of Official Analytical Chemists. 18th Edition, Washington, DC. 2010.
15. Chopra S. L., Kanwar J. S. Analytical Agricultural Chemist, 4th edition, Kalyani Publisher, New Delhi. 1991.
16. Lindsey W. L., Norwell M. A. A new DPTA-TEA soil test for zinc and iron. Agronomy Abstract. 1969; 61:84-89. DOI: https://doi.org/10.2136/sssaj1978.03615995004200030009x
17. Rao B. S. N., Prabhavathi T. An in vitro method for predicting the bioavailability of iron from foods. *American Journal of Clinical Nutrition.* 1978; 31:169. DOI: https://doi.org/10.1093/ajcn/31.1.169
18. Kim H., Zemel M. B. In vitro estimation of the potential bioavailability of calcium from sea mustard milk and spinach under stimulated normal and reduced gastric acid conditions. *Journal of Food Science.* 1986; 51: 957-963. DOI: https://doi.org/10.1111/j.1365-2621.1986.tb11207.x
19. Tripathi J. Impact of supplementation with leaf powder mix incorporated nutri flour based iron rich products on the nutritional status of school going children living in jasra block of Allahabad district. Ph.D. Thesis, SHUATS, Allahabad. 2018.
20. Singh G. Development and nutritional evaluation of value added products from pearl millet (*Pennisetum glaucum*). Ph.D. Thesis. CCS. Haryana Agricultural University, Hisar, India. 2003.
21. Rajni. Development and Nutritional Evaluation of Pearl Millet (*Pennisetum glaucum*) Based Value Added Products Incorporating Carrot and Cauliflower Leaves. M. Sc.Thesis, CCS HAU, Hisar, India. 2019.
22. Savita. Development and Nutritional Analysis of Pearl Millet Based *Jamun* (*Syzygium cumini* L.) Seeds Incorporating Value Added Products. M.Sc. Thesis, CCSHAU, Hisar, India. 2018.
23. Rajbala. Improvement in nutritional status of school children through micronutrient rich dietary supplements.Ph.D. Thesis, CCS Haryana Agricultral University, Hisar, India. 2010.
24. Dubey P., Dubey R., Ramakant, Saxena K. Preparation of value added weaning food products for infants using flours of germinated cereals and pulses. *Advances in Life Science*. 2012; 1(2): 152-156.
25. Kaur A., Kochhar A. Sensory and nutritional evaluation of value added products using potato flour for nutritional and health benefits. *International Journal of Medical Science*. 2014; 7(2): 1-6. DOI: 10.15740/HAS/IJMS/7.1and2/1-6
26. Mishra J. Developments of micronutrients rich food products and their effect on level on school going children (6-8 years) Ph.D. Thesis. SHUATS, Allahabad (UP). 2018.
27. Yadav S. S. Punia D., Khetarpaul N. Nutrient composition of products prepared by incorporating amaranth (*Amaranthus tricolor*) leaf powder. *Nutrition & Food Science*. 2009; 39(3): 218-225. DOI: http://dx.doi.org/10.1108/00346650910957465
28. Singh G. Development and nutritional evaluation of iron and β-carotene rich products. M.Sc. Thesis, CCSHAU, Hisar. 1999.

*Corresponding Author: **Manohar Lal**

29. Divakar S. A., Prakash J. Quality parameters and shelf stability of millet based '*Khakhra' Journal of Food Science and Technology*. 2021; 51(6): 1021-1040. DOI: https://doi.org/10.22271/tpi.2021.v10.i1d.5525
30. Lal M., Godara P., Upadhya S., Kaur J. Effect of curry leaves supplementation on the sensorial and nutritional attributes of fermented food products. *International Journal of Home Science.* 2024; **10**(3):301-309. DOI: https://dx.doi.org/10.22271/23957476.2024.v10.i3e.1711
31. Bansal T. Development of bio-fortified pearl millet-based value-added products incorporating carrot and sesame seeds. M.Sc. Thesis, CCSHAU, Hisar, India. 2018.
32. Rao R. Development of grits from processed and unprocessed pearl millet and its utilization in product development. M. Sc.Thesis, CCS HAU, Hisar, India. 2015.
33. Rani S. Nutritional evaluation and utilization of biofortified pearl millet in product development. M.Sc. Thesis, CCSHAU, Hisar, India. 2017.

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