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Research Article

Sensory And Nutritional Evaluation Of Iron-Enriched Sprouted Pennisetum Glaucum Seed Products

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ABSTRACT

Germination is a cost-effective technique to improve the nutritional quality of millet seeds. Pennisetum glaucum seed is an important coarse grain crop in western India. Its potential for future human use is significant due to its ability to tolerate challenging growing conditions such as drought, poor soil fertility, and high temperatures. It can be cultivated in regions suitable for the growth of other grains like corn and wheat Pennisetum glaucum contains large amounts of minerals such as iron, calcium, and zinc, and is also high in fat. Nutritionally it is comparable to the most important types of grains and superior to them due to its energy and protein value. In contrast to the institutional support for wheat, rice, and maize, and Pennisetum glaucum seed cultivation continues to shrink due to the absence lack of institutional support for millet cultivation. Pennisetum glaucum is highly nutritious but is underutilized in developed countries as it is not available in a convenient ready-to-eat form. This study aims to address this issue by using wheat flour and sprouted pearl millet flour in different proportions to produce value-added products such as biscuits, ladoo, and namakpara. . The nutritional content of these products is characterized and their acceptability evaluated by sensory analysis by a panel of judges. This study highlights the potential of incorporating sprouted gray millet into daily snacks to improve the nutritional profile and overall acceptability of these products.

Keywords: Pennisetum Glaucum, Sensory Evaluation ladoo, biscuit, namakpara

INTRODUCTION

Pennisetum glaucum commonly known as bajra, holds significant importance as a coarse cereal crop in regions like western India, particularly in states such as Gujarat, Rajasthan, and Haryana. Its resilience to adverse growing conditions such as poor soil fertility, and high hot temperatures makes it a valuable staple in areas where other different millets crop struggle to thrive. Despite its nutritional richness, including notable contact of calcium, zinc, iron and fats, Pennisetum glaucum remains underutilized, due to the absences of institutional support compared to more popular grains like wheat, rice, and maize.

To enhance the nutritional value of Pennisetum glaucum and make it more accessible, researchers have explored various processing techniques. One such approach is germination is a cost-effective method to increase the nutritional quality of millet seeds. Germination not only increases the bioavailability of nutrients but also improves digestibility.

In this context, there was formulation of iron-rich value-added products using germinated Pennisetum glaucum These products, including ladoo, biscuit, and namakpara, are aimed at not only improving the nutritional quality of Pennisetum glaucum but also diversifying its consumption by offering convenient and ready-to-eat options.

The development of these products involves procuring locally available iron-rich ingredients such as Pennisetum glaucum moth bean, rice flakes, and garden cress seeds. These ingredients are carefully processed, including cleaning, soaking, and germination, to ensure their suitability for product development. Standardization of recipes is carried out by varying the proportions of Pennisetum glaucum flour in conjunction with other ingredients like wheat flour, sugar, ghee, and oil.

Following the development of these products, organoleptic evaluation becomes crucial to determine their acceptability. A panel of judges evaluates the products based on attributes such as color, appearance, flavor, taste, texture, and all attributes acceptability using a hedonic scale. The results of this sensory analysis guide the selection of acceptable formulations for other analysis include nutritional evaluation.

This research aims not only to enhance the nutritional quality of Pennisetum glaucum but also to promote its consumption by offering palatable and nutritious value-added products. By leveraging the benefits of germinated Pennisetum glaucum, this study contributes to addressing the nutritional challenges and promoting the utilization of underutilized grains in the diet, thereby fostering food security and dietary diversity.

Which is an important phenomenon for calcium accretion in bone and bone growth. Depending on the variety and type of millet, it generally has high iron, and protein content. Different Millets have the potential to improve the blood hemoglobin concentration compared to polished white rice (Anitha *et al.,* 2024).

In the present era of world environment fluctuations, water insufficiency, accumulative population, increasing food prices, and socio-economic are expected to generate a great threat to health and food security worldwide, especially for the poorest people living in under-developed and developing countries such as Africa and Asia continents. Also, the method of agriculture has changed over the period of time with more water requirements and excessive usage of fertilizers. It affects the human health with fatal disease such as cancer becoming more common. Out of a total of twelve grains, some are classified as positive, negative, and neutral. Among them, kodo millet, little millet, barnyard millet, brown top millet, and foxtail millet fall into the category of positive grains. Millet is cultivated in various parts of the Indian subcontinent and serves as a significant source of carbohydrates and proteins for the inhabitants of these regions. Additionally, due to its vital contribution to national food security and potential health benefits, millet grains are garnering increasing interest from food scientists, researchers, technologists, and nutritionists. Numerous previous reviews have examined their role in enhancing human health. However, there is currently a lack of comprehensive research on millet-derived peptides and their alleged impact on human health. The objective of this study was to assess the nutritional quality and potential health benefits of millet grains by reviewing the extensive research conducted to date. (Bhatt et al., 2022, "Millet food products: Traditional medicinal diet for modern lifestyle health issues.

MATERIALS AND METHODS:

The formulation and sensory evaluation of iron-rich food products derived from Pennisetum glaucum.

1.1 Development of products

1.2 Sensory evaluation

1.1 Development of products

Various iron rich nutritious recipes were developed in the food and nutrition laboratory at B. P. S M Khanpur Kalan Sonipat using locally available iron rich product i.e. Pennisetum glaucum

Plate 1: Food Products lab

Procurement of material

Pennisetum glaucum, were as obtained in a local market of Gohana . The remaining ingredients namely sugar, ghee, oil and other condiments were purchased from Gohana market Sonipat.

Processing of grains

The seeds were cleaned thoroughly to remove any dust, dirt, or foreign material before being processed and developed into products. Subsequently, the raw ingredients were dried and stored under clean and hygienic conditions for future use.

Germination process

Pennisetum glaucum grains were initially cleaned to remove broken seeds, dust, and other foreign materials, and then soaked in tap water for 12 hours at 37°C. A seed-to-water ratio of 1:5 (weight/volume) was maintained. The absorbed water was discarded. The soaked seeds were then germinated in sterile petri dishes lined with moist filter paper for 48 hours at 37°C, with regular watering. The sprouts were subsequently rinsed in distilled water and dried at temperatures ranging from 50°C to 55°C.

Specification of Pennisetum glaucum based products

The recipes for preparing different products from Pennisetum glaucum flour were standardized across three levels (5g, 10g, and 15g). The recipe deemed acceptable and chosen from these three levels was evaluated further for nutritional analysis.

Table 1: Products from iron rich cereals /pulses and nut seeds

Products	**Level of cereals /pulses, nut and oilseed powder(gm)**		
Sprouted Pennisetum glaucum based products	**I**	**II**	**III**
Pennisetum glaucum flour biscuit	5	10	15
Pennisetum glaucum flour *namakpara*	5	10	15
Pennisetum glaucum flour *Ladoo*	5	10	15

RECIPES OF PRODUCTS

Pennisetum glaucum Based Products

Plate 2: Sprouted and non-sprouted Pennisetum glaucum seeds

Table 1.2: *Ladoo* Flour content (%)

Ingredients	**Control**	**I**	**II**	**III**
Bangal gram flour (g)	100	95	90	85
SproutedPennisetum glaucum flour (g)	-	5	10	15
Sugar (g)	70	70	70	70
Ghee (g)	60	60	60	60

Method

Here are the steps formatted properly:

1. Roast Pennisetum glaucum flour in ghee until golden brown. 2. Mix in powdered sugar and cardamom powder. 3. Let the mixture cool. 4. Shape into small balls (ladoos) using your hands. 5. Optional: Garnish with chopped nuts. 6. Let the ladoos set for 30 minutes before serving.

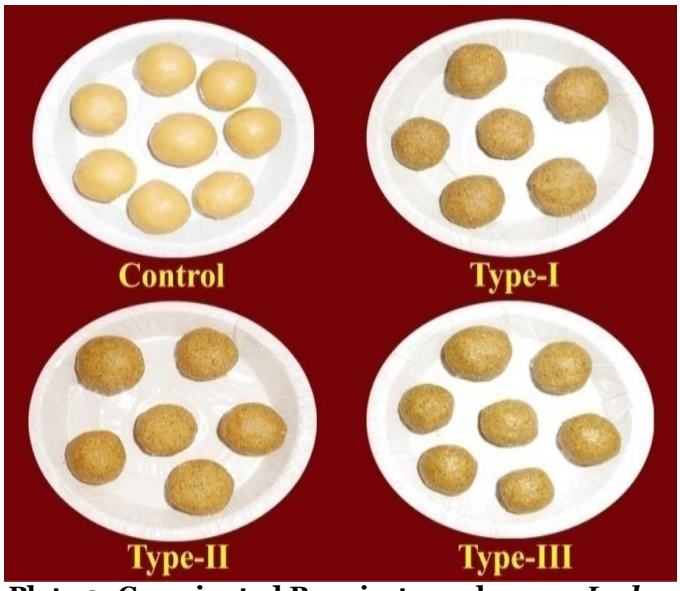

Plate 3: Germinated Pennisetum glaucum *Ladoo*

Control = 100% Cicer arietinum Flour
Type-I = 95% Cicer arietinum.Flour + 5% Pennisetum glaucum
Type-II = 90% Cicer arietinum. flour + 10% Pennisetum glaucum
Type-III = 85% Cicer arietinum. flour + 15% Pennisetum glaucum

Table 1.3: *Namakpara* Flour content (%)

Ingredients	Control	I	II	III
Refined wheat flour (g)	100	95	90	85
Sprouted Pennisetum glaucum flour (g)	-	5	10	15
Ajwain (g)	3	3	3	3
Salt (g)	2	2	2	2
Oil (ml)	For Frying			

Method

- Sieved the refined flour and sprouted Pennisetum glaucum flour
- Added salt and *ajwain*.
- Rubbed a teaspoon of fat in flour and made it to smooth dough using lukewarm water.
- Rolled the dough into thin layer and cut into small square pieces
- Heated the oil and deep-fried the *namakpara* until golden brown in colour.

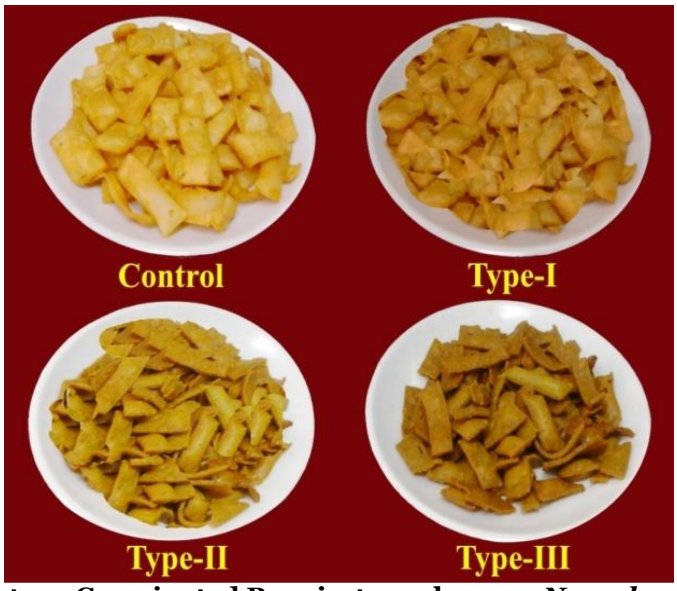

Plate 4. Germinated Pennisetum glaucum *Namakpara*

Control = 100% Refined wheat flour
Type-I = 95% Refined wheat flour + 5% Pennisetum glaucum
Type-II = 90% Refined wheat flour + 10% Pennisetum glaucum
Type-III = 85% Refined wheat flour + 15% Pennisetum glaucum

Table 1.4: Biscuit Flour content (%)

Ingredients	Control	I	II	III
Refined wheat flour (g)	100	95	90	85
Germinated Pennisetum glaucum flour (g)	-	5	10	15
Milk (g)	25	25	25	25
Ground sugar (g)	40	40	40	40
Ghee (g)	40	40	40	40

Method:

- Sieved refined flour and sprouted Pennisetum glaucum flour .
- Creamed ghee, sugar and milk.
- Added sodium bicarbonate and creamed again.
- Added the sieved flours and mixed well.
- Rolled on the board and cut into the shape of biscuits with the help of biscuit cutter.
- Baked the biscuits at 160°C for 15 to 25 minutes till brown.

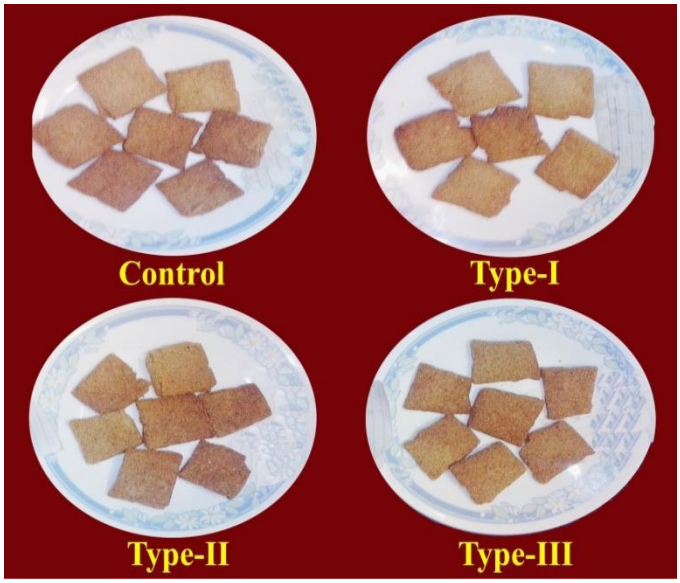

Plate 5: Sprouted Pennisetum glaucum Biscuits

Control = 100% Refined wheat flour
Type-I = 95% refined wheat flour + 5% Pennisetum glaucum
Type-II = 90% Refined wheat flour + 10% Pennisetum glaucum
Type-III = 85% Refined wheat flour + 15% Pennisetum glaucum

Sensory evaluation of developed food products

For selecting the acceptable products for further study, the products prepared using three levels (5%, 10% and 20%) of Pennisetum glaucum flours were evaluated organoleptically for their colour, appearance, flavor, taste, texture and overall acceptability using a nine-point Hedonic Scale by panel of 10 judges from the B.P.S.M.V. Khanpur Kalan Sonipat. From every food product level having superior, acceptability was selected for further nutritional analysis .

Selected products	flours use (g)
Pennisetum glaucum *ladoo*	15
Pennisetum glaucum *namakpara*	15
Pennisetum glaucum Biscuit	15

RESULT

4.3 Sensory evaluation of products.

Sprouted Pennisetum glaucum food supplement Biscuit

Biscuits made with the addition of Pennisetum glaucum flour were subjected to sensory evaluation by panel members, considering attributes such as color, appearance, flavor, texture, taste, and overall acceptability. The control biscuit received scores ranging from 8.00 to 8.40 across different attributes. Incorporating 5% of Pennisetum glaucum flour led to a decrease in scores for all sensory attributes but was still rated as "desirable" for most attributes and "moderately desirable" for aroma. However, biscuits with 10% incorporation of sprouted Pennisetum glaucum flour were considered "desirable" in all aspects. Further increasing the incorporation to 15% resulted in improved sensory attributes, with these biscuits being better accepted compared to control, 5%, and 10% incorporation levels. Anu et al. (2008) formulated supplements using blanched Pennisetum glaucum flour, refined wheat flour, and green gram flour, with certain combinations being highly favored. Additionally, sensory evaluations of Pennisetum glaucum value-added products have been found acceptable in various studies (Singh and Mehra, 2017; Johari and Kawatra, 2018; Kumari, 2018; Kalange et al., 2020; Phalphale et al., 2021; Bansal et al., 2022).

Namakpara

The sensory attributes of Namakpara made with sprouted Pennisetum glaucum flour at levels of 5%, 10%, and 15% are detailed in Table 1.5. The control Namakpara scored between 7.90 and 8.20, rated as desirable for color, appearance, aroma, texture, and overall acceptability, and moderately desirable for taste. Results indicate that Namakpara incorporating 5% flour was considered desirable across all sensory aspects. Namakpara with 10% flour was desirable in appearance, aroma, texture, taste, and overall acceptability, while moderately desirable in color. Incorporating 15% flour resulted in improved scores across all sensory attributes, rated as desirable. Namakpara with 15% Pennisetum glaucum flour was better accepted compared to the control and supplemented Namakpara. Archana (2001) prepared various products using bleached Pennisetum glaucum millet and found them to be highly acceptable in terms of color, appearance, and taste compared to those made from unbleached Pennisetum glaucum. Anju (2005) developed products using white and yellow varieties of Pennisetum glaucum, including cakes, biscuits, bakli, suhali, noodles, and popped laddoo, and observed that products made from yellow Pennisetum glaucum varieties were preferred over those from grey Pennisetum glaucum variety.

Ladoo

The ladoo prepared without the incorporation of sprouted Pennisetum glaucum (control) were rated as 'moderately desirable' in all aspects. The control ladoo received scores ranging from 7.40 to 7.70 for different attributes. Incorporating 5% Pennisetum glaucum flour increased the scores for all sensory attributes, rated as 'moderately desirable' for color, aroma, taste, and overall acceptability, and 'desirable' for appearance and texture. Adding 10% Pennisetum glaucum flour resulted in scores ranging from 7.70 to 8.30 for all attributes, with a rating of 'desirable' for appearance, aroma, texture, taste, and overall acceptability. However, the ladoo prepared with 15% germinated Pennisetum glaucum flour was deemed 'desirable' by judges for all sensory characteristics, with taste being notably better compared to the control. Rajbala (2010) prepared value-added products such as ladoo, burfi, mathi, chapatti, and halwa from pearl millet flour, green gram flour, Bengal gram flour, gingelly seeds, groundnut, and various fruit/vegetable powders, finding them acceptable in terms of color, texture, taste, appearance, and overall acceptability. Pelembe et al. (2002) investigated the effect of malting conditions on Pennisetum glaucum malt quality in two cultivars, reporting that germination at temperatures between 25-30°C for 3-5 days resulted in optimal α and β-amylase activity and moderate malting loss.

Table 1.5 : The scores for different attributes of biscuits, namakpara, and ladoo prepared with sprouted Pennisetum glaucum flour were determined.

Products	Color	Appearance	Aroma	Texture	Taste	Over all acceptability
Biscuits						
Control	8.10 ± 0.23^{b}	8.00 ± 0.25^{c}	8.10 ± 0.31^{b}	8.20 ± 0.29^{b}	8.40 ± 0.16^{ab}	8.16 ± 0.22^{b}
Type I	8.00 ± 0.21^{b}	8.00 ± 0.25^{c}	7.70 ± 0.21^{c}	8.10 ± 0.27^{b}	8.30 ± 0.21^{b}	8.02 ± 0.21^{b}
Type II	8.00 ± 0.21^{b}	8.30 ± 0.15^{b}	8.40 ± 0.16^{a}	8.50 ± 0.16^{a}	8.60 ± 0.15^{a}	8.30 ± 0.11^{ab}
Type III	8.40 ± 0.22^{a}	8.50 ± 0.16^{a}	8.60 ± 0.16^{a}	8.60 ± 0.16^{a}	8.70 ± 0.16^{a}	8.54 ± 8.14^{a}
CD(P<0.05)	0.62	0.61	0.63	0.66	0.50	0.51
Namakpara						
Control	8.00 ± 0.29^{a}	8.20 ± 0.20^{b}	8.10 ± 0.34^{b}	8.00 ± 0.33^{b}	7.90 ± 0.31^{b}	8.04 ± 0.27^{b}
Type I	8.00 ± 0.29^{a}	8.20 ± 0.24^{b}	8.15 ± 0.20^{b}	8.40 ± 0.16^{a}	8.50 ± 0.16^{a}	8.21 ± 0.17^{ab}
Type II	7.90 ± 0.31^{a}	8.30 ± 0.26^{ab}	8.30 ± 0.21^{a}	8.50 ± 0.16^{a}	8.50 ± 0.22^{a}	8.24 ± 0.18^{a}
Type III	8.00 ± 0.25^{a}	8.40 ± 0.22^{a}	8.30 ± 0.26^{a}	8.50 ± 0.22^{a}	8.60 ± 0.16^{a}	8.34 ± 0.18^{a}

CD(P<0.05)	0.84	0.67	0.75	0.66	0.64	0.60
Ladoo						
Control	7.60±0.22^{c}	7.70±0.26^{c}	7.40±0.22^{c}	7.40±0.16^{c}	7.70±0.21^{c}	7.56±0.17^{c}
Type I	7.80±0.24^{b}	8.00±0.25^{b}	7.90±0.27^{b}	8.10±0.18^{b}	7.90±0.23^{c}	7.94±0.21^{b}
Type II	7.70±0.26^{bc}	8.20±0.20^{ab}	8.20±0.20^{a}	8.30±0.21^{a}	8.30±0.21^{b}	8.14±0.16^{ab}
Type III	8.10±0.23^{a}	8.40±0.22^{a}	8.20±0.24^{a}	8.30±0.21^{a}	8.60±0.22^{a}	8.32±0.19^{a}
CD(P<0.05)	0.69	0.67	0.68	0.55	0.63	0.53

The values presented are the mean ± standard error (SE) calculated from evaluations by ten panelists. Values sharing the same superscript do not exhibit significant differences, as determined by the critical difference (CD) at a significance level of P≤0.05.

CONCLUSION

The utilization of germinated Pennisetum glaucum in the development of value-added food products such as biscuits, *ladoo,* and namakpara presents a promising opportunity to enhance both the nutritional value and accessibility of this underutilized grain. Through sensory analysis, it was discovered, that incorporating germinated Pennisetum glaucum flour in these products not only improves their nutritional profile but also enhances their overall acceptability. This research highlights the significance of broadening food choices, particularly in areas where staple grains such as Pennisetum glaucum are crucial for ensuring food security. Further investigation and advocacy for value-added food products like these could substantially address nutritional gaps and encourage healthier dietary preferences.

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