Development of Nutrient-Rich panipuri fortified with moringa leaves powder

[1]Amit A. Wankhede, [2]Ganesh R. Pandhre

[1]Student of M.sc food technology, [2]Assistant Professor

[1]Department of Chemical Technology, Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar, India

[1]amitwankhede1211@gmail.com, [2]ganeshpandhre@rediffmail.com

***Abstract*— In this research, we investigated the impact of adding dried moringa leaves powder to panipuri-a popular and traditional Indian street food. We compared four formulations: T0 (control), T1 (3% moringa leaves powder), T2 (6% moringa leaves powder), and T3 (9% moringa leaves powder).The results revealed significant differences in nutrient content. Specifically, T3 had significantly higher levels of ash, protein, carbohydrate, energy, calcium, and iron compared to the other samples. On the other hand, T0 had the highest fat content, while T1 had the lowest moisture content. During sensory evaluation, T1 received high acceptance due to favorable color, taste, aroma, and overall appeal. T0 also received positive feedback. However, T2 and T3 received slightly lower ratings in certain attributes. Regarding color analysis, T0 exhibited the lightest color, T3 the darkest, and T1 and T2 had intermediate values. Incorporating up to 3% moringa leaves powder in semolina-based panipuri resulted in a fortified product with improved nutrition and sensory attributes. This innovation holds significant potential for addressing nutritional deficiencies and creating new business opportunities in the food industry.**

***Key words*—Traditional snacks, Panipuri, Moringa *oleifera*, Fortification**

I. INTRODUCTION

Background

Panipuri is a popular street snack, also known as Phuchka in West Bengal and Assam, Golgappe in most of North India (excluding Haryana), Pakodi in Gujarat, Panipuri ke patashe in Haryana, Patashi in Rajasthan and Uttar Pradesh, and Gup chup in Odisha, South Jharkhand, Chhattisgarh, Uttar Pradesh, and some parts of Nepal. It is called Tikki only in Hoshangabad, Madhya Pradesh, Padaka in Aligarh, Uttar Pradesh, and Water Balls (a literal translation of Panipuri). Panipuri, also known as Golgappe, is made up of small, crispy puris filled with spices, tamarind water, chutney, chickpeas, potatoes, and spices. Panipuri, which originated in the Indian subcontinent, has grown in popularity as a street food in many regions (Dr. Sen et al.,2017). *Moringa oleifera* Lam., a prominent species within the Moringaceae family, holds significant importance as a widely cultivated pan-tropical plant. Originating from the southern foothills of the Himalayas in north-western India, Afghanistan, Pakistan, and Bangladesh, M. oleifera is recognized by various regional names such as benzolive, horseradish tree, and drumstick tree (Dhakar et al., 2011). India, currently the largest producer, satisfies approximately 80% of the global demand for M. oleifera (Hutchinson, 2014) The taxonomic classification if Moringa tree are shown in table 1.

II. Fortification

it means deliberately increasing the content of essential micronutrients in a food so as to improve the nutritional quality of food and to provide public health benefit with minimal risk to health. The main goal of fortification is to address nutrient deficiencies in the population and enhance the nutritional quality of foods.

Table 1: Taxonomic Classification

Kingdom	**Plantae**
Sub-kingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Sub class	Dilleniidae
Order	Capparales
Family	Moringaceae
Genus	*MORINGA*
Species	*oleifera*

Adopted from Saini et al (2013)

III.REVIEW OF LITERTURE

Moringa oleifera

Moringa oleifera, native to India, grows in the tropical and subtropical regions of the world. It is commonly known as 'drumstick tree' or 'horseradish tree'. Moringa oleifera belonging to the family of Moringaceae (Dhakar et al., 2011). Moringa is a plant that has been extensively researched for its nutritional benefits, particularly in populations with nutrient- deficient diets. It is often used in supplements and as an additive to various foods to combat malnutrition. (Leone, et al., 2018).

Studies have shown that Moringa leaves and powder can have a significant impact on lactating mothers and infants aged 0-6 months. (Zakaria, et al., 2018). These leaves are rich in nutrients like protein, antioxidants, vitamins, and polyphenols, making them an important part of a healthy and balanced diet. The scientific effort of this research provides insights on the use of miracle trees leaves as a fortificant for development of nutrient-rich panipuri.

Phytochemistry

Different parts of the M. oleifera tree contain various beneficial compounds such as glucosinolates, flavonoids, phenolic acids, carotenoids, tocopherols, polyunsaturated fatty acids, minerals, and folate. Glucomoringin is the most abundant glucosinolate in the stem, leaves, flowers, pods, and seeds, while benzyl glucosinolate is prominent in the roots. Glucosinolates can be broken down into compounds known for their hypotensive and spasmolytic effects. (Leone et al.,2015)

Flavanol, glycosides, quercetin and kaempferol are predominantly found in different parts of the tree, except the roots and seeds. The leaves of M. oleifera are rich in omega-3 and omega-6 polyunsaturated fatty acids. The tree also contains significant amounts of potassium, calcium, and magnesium. Indian varieties of M. oleifera have higher levels of quercetin and kaempferol compared to African indigenous samples. The high concentration of these compounds contributes to the tree's potent antioxidant activity. (Leone et al.,2015)

Health Benefits

Every part of the M. oleifera plant has been reported to exhibit medicinal properties such as antioxidant, antidiabetic, anti-obesity, anticancer, hepatoprotective, nephroprotective, neuroprotective, antibacterial, and antiviral activities, etc

Antioxidants

Different parts of the Moringa plant, such as leaves, seeds, flowers, and pods, contain various antioxidants like ascorbic acid, beta-carotene, kaempferol and quercetin. The antioxidants in Moringa oleifera help protect our cells from oxidative stress, which is linked to various diseases like cancer, heart disease, and aging. (Kumar et al.,2012), (Kumar and Pandey.,2013), (Mahajan et al.,2007).

Antidiabetic & Anti-obesity activity

Diabetes is a condition where the body has trouble regulating blood sugar levels. Moringa oleifera has been studied for its potential to help manage diabetes. Moringa contains compounds like terpenes, quercetin-3-glycoside, rutin, and kaempferol, which may help lower blood sugar levels. Moringa oleifera not only does it have antidiabetic properties, but it has been also reported to have anti-obesity properties (Nahar et al.,2016). Moringa has been shown to influence the release of adipokines, such as leptin, adiponectin, and resistin, which play a role in obesity and diabetes.

Hepatoprotective activity

Studies have shown that Moringa extracts can help normalize the levels of liver enzymes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP). Elevated levels of these enzymes indicate liver damage, and Moringa may help reduce them. (Toppo et al,.2015) and (Sharifudin et al,.2013)

Neuroprotective effect

Studies have shown that Moringa can modulate brain monoamines, which are neurotransmitters involved in mood regulation and cognitive function. By influencing these chemicals, Moringa may help improve brain health and function. Ganguly et,al.,(2008).

Anti-inflammatory Activity

Moringa's bioactive compounds can inhibit enzymes like cyclooxygenase-2 (COX-2) and inducible nitric oxide synthase (iNOS) that are involved in the inflammatory process, thereby reducing inflammation and its detrimental effects. Fard et al. (2015)

Antibacterial and antifungal activity

Moringa oleifera demonstrates antibacterial and antifungal activities due to its bioactive compounds. Compounds like benzyl isothiocyanate can inhibit the growth and proliferation of bacteria by targeting specific cellular components essential for their survival. Compounds n Moringa, such as kaempferol and other flavonoids, can target specific fungal components to exert their antifungal effects. (Walter et.al., 2011).

Moringa fortified products

Moringa oleifera is added to traditional amala dough, ogi, bread, biscuits, yogurt, cheese, & soups to enhance their nutritional value. (Adewumi et.al.,2016)

Amala (Stiff Dough): Moringa oleifera is added to amala, a traditional stiff dough made from yam, cassava, or plantain flour. The addition of Moringa enriches the amala with essential nutrients, making it a more nutritious food.

Ogi (Maize Gruel): Moringa oleifera is incorporated into ogi, a maize gruel, to increase its nutritional content. By adding Moringa to ogi, the gruel becomes a more nutrient-dense and wholesome meal option.

Bread: Moringa oleifera is used in bread-making to fortify the bread with additional nutrients. By including Moringa in bread recipes, consumers can enjoy bread that not only tastes good but also provides extra health benefits

Biscuits: Moringa leaves are utilized in biscuit preparation to enhance the nutritional profile of the snacks. Biscuits containing Moringa offer a convenient way to consume this nutritious plant and enjoy its health-promoting properties.

Yoghurt: Moringa-probiotic yogurt is created by combining Moringa with ingredients like banana, sweet potato, or avocado. This fortified yogurt provides a delicious and nutritious snack option that supports gut health and overall well-being.

Cheese: Dry leaves of Moringa oleifera can be added to Labneh, a type of cheese, to enhance its nutritional value. This innovative dairy product provides a unique way to incorporate Moringa into the diet.

Soups: Moringa leaves, seeds, or flowers are used in soup recipes to increase their nutritional content. Adding Moringa to soups enhances their nutrient profile and introduces the health benefits of Moringa into everyday meals

IV.MATERIAL AND METHODOLOGY

Raw Materials - Moringa leaves were collected from Dr. Babasaheb Ambedkar Marathwada University campus while other ingredients were procured from the local market.

Raw materials for Moringa fortified puri preparation

1. Moringa leaves powder
2. Semolina
3. Water
4. Salt
5. Baking soda
6.Oil

Ingredients for stuffing

1. Potatoes
2.cumin seed
3.coriander
4.onion
5.Black salt.

Ingredients for water of Panipuri

1.Coriander leaves
2. Tamarind pulp
3. Mint leaves
4. Green chilli
5. Black salt
6. Crushed jaggery
7. Water

Role of basic ingredients

1. Moringa leaves: Moringa leaves are a rich source of essential nutrients such as vitamins, minerals, and antioxidants. They add nutritional value to the puris by providing nutrients.

2. Semolina: Semolina is the main ingredient in puri dough and provides structure and texture to the final product. It adds a crispiness to the puris when fried and contributes to the overall taste and mouthfeel.

3. Oil: Oil is used for frying the puris and helps in achieving a crispy and golden-brown exterior. It also adds flavour to the puris and aids in the cooking process.

4. Water: Water is used to hydrate the dough and bind the ingredients together. It helps in forming a smooth and pliable dough that can be rolled out easily.

5. Salt: Salt enhances the flavour of the puris and balances the taste of other ingredients.

6. Baking soda: Baking soda is a leavening agent that helps the puris puff up when fried. It reacts with acidic ingredients in the dough to produce carbon dioxide gas, which creates air pockets in the puris, making them light and fluffy

Methods

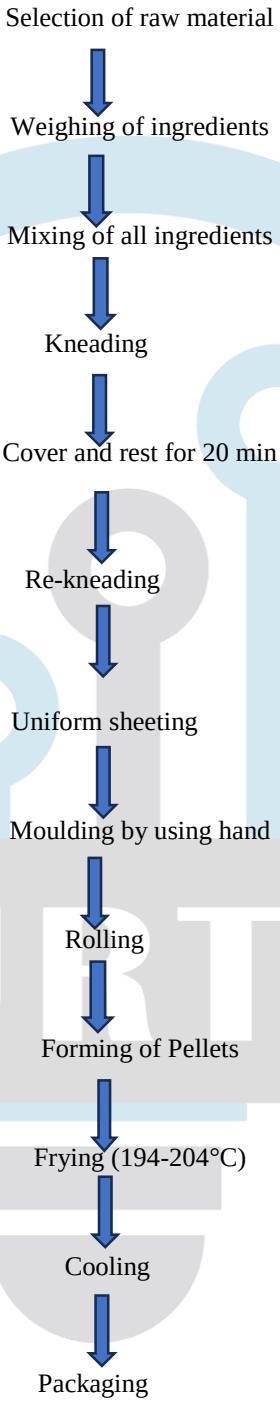
Preparation of control sample

Wheat flour, Maida & semolina were individually taken for making the control sample puris.

Table 2: Control sample Formulation

Ingredients	Quantity (In Percentage)
Wheat flour	100%
Maida	100%
Semolina	100%

Flow sheet for control sample



The same procedure was followed for all control samples. Semolina was choosen for moringa leaf fortification due to its ability to maintain proper texture

Preparation of Moringa leaf powder

Drying of fresh Moringa oleifera leaves was carried out, with slight modification, following methods reported by Satwase et al & Pandhre et al (2010).

Fresh moringa leaves were sorted & young and fresh leaves were selected. Leaves were washed with clean water to remove all dirt. The washed and dried leaves were then dried in a cabinet tray drier at 60 degrees Celsius for 4 hr. The dried leaves were sieved & stored in glass container.

Formulation of fortified moringa puri

The formulation & preparation of fortified Moringa puri with different ratios shown in following table.

Table 3: Formulation and ratios for fortified moringa puri

Ingredients	Formulation	Ratios
Semolina + moringa leaf powder	T1	97:3
Semolina + moringa leaf powder	T2	94:6
Semolina + moringa leaf powder	T3	91:9

Formulation details

T1- 97% Semolina with 3% Moringa leaf powder
T2 - 94% Semolina with 6% Moringa leaf powder
T3 - 91% Semolina with 9% Moringa leaf powder

Procedure

Puri

1. In a large mixing bowl take the semolina moringa leaves powder and Maida. Add baking soda & salt. Combine all the ingredients well.
2. Knead the mixture with water to form a smooth and soft dough. Add water as needed.
3. Cover and rest for 20 minutes or until the semolina absorbs moisture. Now knead the dough again making sure the dough is stiff absorbing moisture.
4. Divide the dough into half and dust with Maida flour. Roll the dough as thin as possible using a rolling pin.
5. Using a small cookie cutter, begin to cut out small circles. Drop the circles in heated oil and press with the spoon to help it puff up.
6. Once they puff, it will automatically turn over.
7. Fry the puri till golden brown and crisp. Remove the puri and drain over tissue paper to remove excess oil.

Procedure for pani

For Sweet water

1. Into a pressure cooker add jaggery, tamarind, and water. Pressure cook for 3 to 4 whistles.
2. Turn off the heat and allow the pressure to release naturally.
3. Once released open the pressure cooker and with the help of a hand blender, blend the tamarind to make a coarse mixture.

For Spicy water

1. Place the pressure cooker back on heat and add the chili powder, cumin powder, coriander leaves, mint leaves, black salt and salt to taste.
2. Add little water to adjust the consistency and simmer for 3 to 4 minutes. Turn off the heat and cool.

For stuffing

1. Boil the potatoes in pressure cooker for 2-3 whistles.
2. After that mash the potatoes
3. chopped onion cumin seeds black salt added into stuffing to get spicy and tasty mouth feeling.

Flow sheet of Preparation of Moringa leaves fortified puri

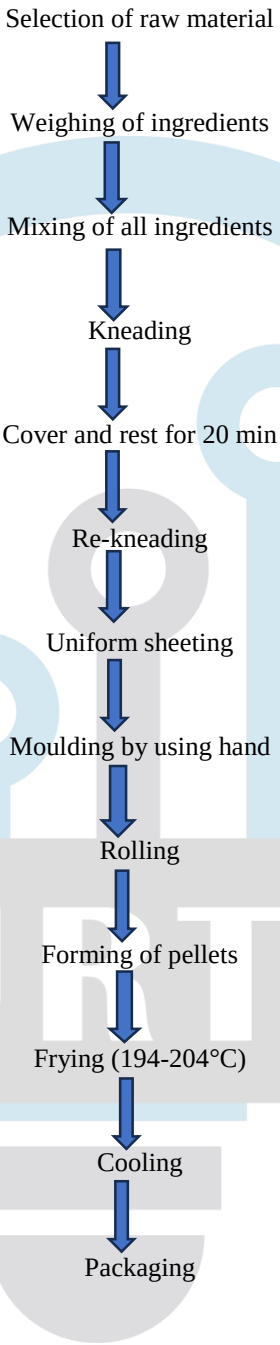
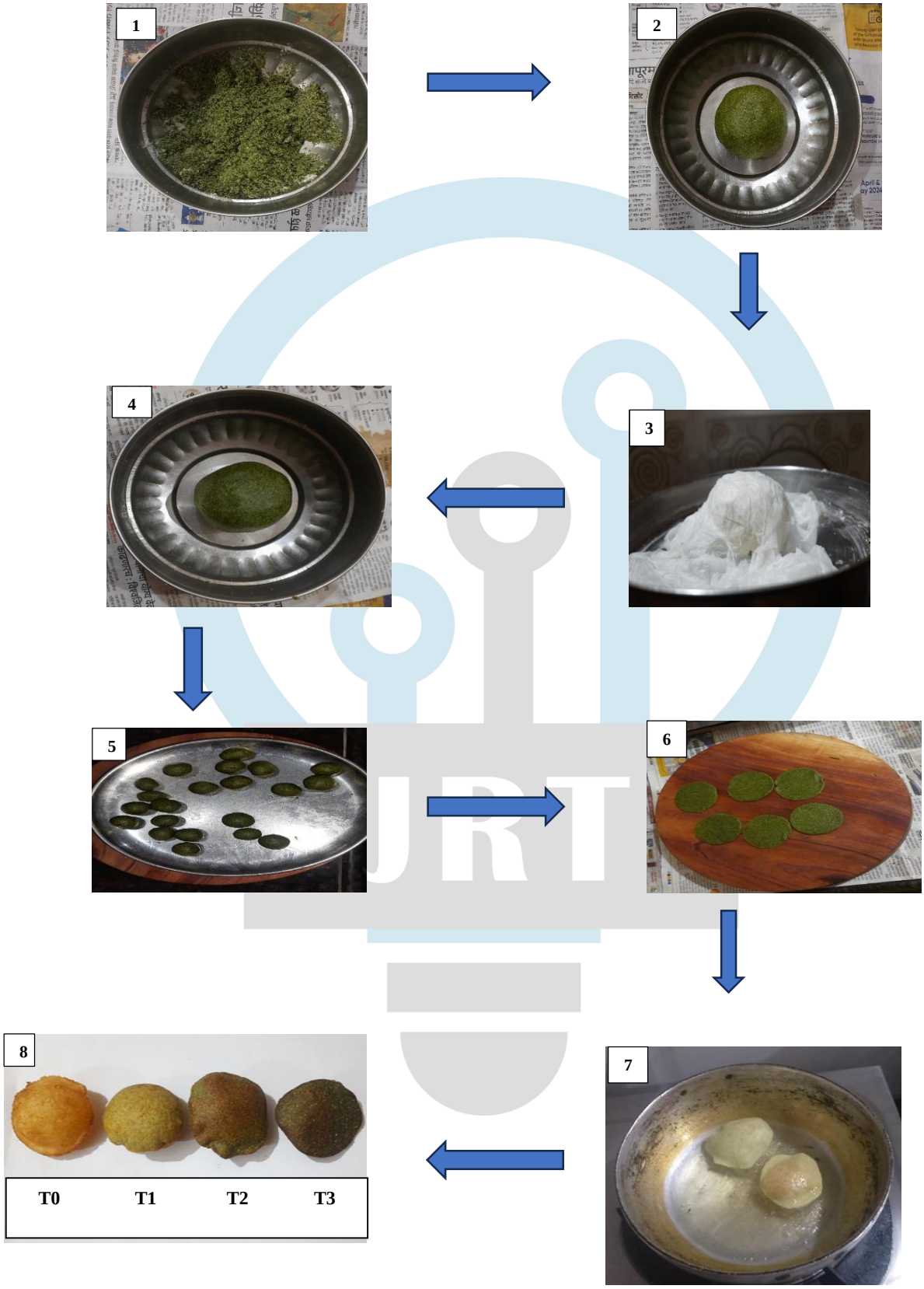


Figure 1: Preparation of moringa fortified puri



V. Result and discussion

Proximate Analysis - Nutrient content of all samples was determined at the MIT CARS laboratory Chhatrapati sambhajinagar. The nutritional analysis of Moringa leaves powder is depicted in following table.

Table 4: Proximate analysis of dried moringa leaves powder

Nutrient parameter	Moringa leaves powder
Moisture (%)	2.09
Ash (%)	11.95
Fat (%)	34.19
Fiber (%)	3.58
Protein (%)	29.76
Carbohydrate (%)	22.01
Energy (kcal)	514.79
Calcium (%)	2.022
Iron (%)	0.033

Moringa leaf powder contains 2.09% moisture. The ash content of the Moringa leaf powder is 11.95%. Moringa leaf powder contains 34.19% fat. Fiber content of the Moringa leaf powder is 3.58%. Protein content of the Moringa leaf powder is 29.76%. The Moringa leaf powder contains 22.01% carbohydrates. Moringa leaf powder provides 514.79 kcal. Moringa leaf powder contains 2.022% calcium. The iron content of the Moringa leaf powder is 0.033.

Table 5: Proximate analysis of moringa fortified panipuri

Nutrient parameter	T0	T1	T2	T3
Moisture (%)	1.54	1.43	1.65	1.88
Ash (%)	0.29	0.49	0.89	0.99
Fat (%)	35.67	22.65	11.79	9.33
Fiber (%)	2.08	1.79	2.18	2.99
Protein (%)	7.43	8.22	8.89	9.35
Carbohydrate (%)	55.07	67.21	75.99	78.45
Energy (kcal)	571.03	505.57	445.63	435.17
Calcium (%)	0.033	0.064	0.151	0.218
Iron (%)	0.006	0.003	0.008	0.017

The nutritional composition of panipuri samples with varying levels of moringa leaves powder addition - T0 (control), T1 (1%), T2 (2%), and T3 (3%) was described as follows:

1. Moisture content: T3 had the highest moisture content, while T1 had the lowest.
2. Ash content: T3 exhibited the highest ash content, significantly higher than the T0. Mouminah also reported a significant enhancement of ash content in their research.
3. Fat content: T0 had the highest fat content, and T3 had the lowest, indicating a reduction in fat content with increasing MLP.
4. Fiber content: T3 had the highest fiber content, followed by T2 and the control, with T1 having the lowest.
5. Protein content: T3 had the highest protein content, demonstrating a increase with increasing MLP levels. Yadav et al in their research also reported a significant increase in protein content upon increasing the levels of MLP.
6. Carbohydrate content: T3 showed the highest carbohydrate content, followed by T2, T1, and the T0.
7. Energy content: T0 had the highest energy value, and T3 had the lowest, indicating a decrease in energy content with increasing Moringa leaves powder.
8. Calcium content: T3 displayed the highest calcium content, significantly higher than the T0, demonstrating a substantial increase with increasing Moringa leaves powder levels. Govender et al & Naicker et al in their research also reported a significant increase in calcium content upon increasing the levels of Moringa leaves powder.
9. Iron content: T3 exhibited the highest iron content, indicating a significant increase in iron content with increasing MLP levels. Tomar et al in their research also reported a significant increase in iron content upon increasing the levels of MLP.

Sensory Evaluation

Sensory evaluation of all samples was done using a semi trained panel of 20 members. The panelists score on the basis of Color, Appearance, flavor, Taste, Aroma and Overall Acceptability on 9-point hedonic scale as desired by FAO.

The results of the sensory analysis are depicted in the following table.

Table 6: Sensory evaluation of moringa fortified panipuri

Samples	Parameters					
	Colour	Appearance	Flavour	Taste	Aroma	Overall Acceptability
T0	8.00±1.02	7.70±0.80	7.20±1.05	7.50±1.20	7.42±1.04	7.65±0.81
T1	7.65±0.93	8.05±0.89	7.30±1.08	7.40±1.09	7.70±0.98	7.70±1.03
T2	7.45±1.14	7.45±1.0	7.10±1.25	7.00±1.34	7.25±0.97	7.30±0.98
T3	7.20±1.20	7.20±0.77	7.10±1.12	6.80±1.28	7.20±1.06	7.20±1.28

Color: T1 (3% Moringa leaves powder) had the most consistent color quality, with the smallest standard deviation, meaning the panelists agreed more on its color.

Appearance: T1 (3% Moringa leaves powder) had the highest average appearance rating, suggesting it was considered the most visually appealing.

Flavor: T1 (3% Moringa leaves powder) had a slightly lower average flavor rating but a lower standard deviation, suggesting more consistent flavor perception.

Taste: T1 (3% Moringa leaves powder) had the highest average taste score and the lowest variability in taste perception, indicating the most consistent taste experience.

Aroma: T1 (3% Moringa leaves powder) had a slightly higher average aroma rating compared to T0 (control) but with a higher variation in aroma perception.

Overall Acceptability: T1 (3% Moringa leaves powder) demonstrated positive attributes in terms of appearance, taste, and aroma, and was considered the most consistent regarding color and taste.

Color Measurement

Table 7: Color measurement of moringa fortified puri

Samples	Parameters		
	L	a	b
T0	56.21±7.89	+8.28±1.16	+28.77±1.24
T1	42.45±1.50	+5.70±1.80	+29.67±1.30
T2	32.92±1.16	+4.62±0.57	+19.85±1.77
T3	31.80±1.11	+3.30±1.01	+18.25±1.36

Color was measured by Konica Minolta color reader.

L* (Lightness): T0 had the highest mean L value, indicating the lightest color attribute. T1 is slightly darker than T0. T2 is significantly darker than both T0 and T1. T3 is the darkest among all groups.

a* (Green-Red Axis): The Control group had the highest mean A value, suggesting a reddish hue.T1 had a slightly lower A value, indicating less redness than T0. T2 tends significantly towards greenish hues. T3 shows a slightly more reddish trend than T2, but less red than T0 and T1.

b* (Blue-Yellow Axis): T0 had the highest mean b value, indicating a yellowish hue. T1 is slightly more yellow than T0. T2 tends significantly towards blue. T3 has the least yellowish trend, potentially leaning towards bluish tones.

Conclusion

Present investigation reveals that to improve public health and create new business opportunities. The study found that adding 3% dried moringa leaves powder to the semolina-based panipuri recipe significantly increased its nutritional value, particularly in protein, calcium, and iron content, while maintaining acceptable sensory attributes. This fortified panipuri (T1 Sample) was well-received by consumers, demonstrating a favorable taste, aroma, and overall acceptability compared to the control sample (T0) and other variations.

This successful fortification strategy presents exciting future prospects for food manufacturers and street food vendors. It opens the door to creating healthier snack options that address nutritional deficiencies while appealing to consumers. Further research and development are needed to optimize the moringa concentration, explore other potential ingredients for fortification, and explore the long-term health benefits of consuming fortified panipuri.

References

1. Dhakar, R.C., Maurya, S.D., Pooniyal, B.K., Bairwal, N., Gupta, M., Sanwarmal, 2011. Moringa: the herbal gold to combat malnutrition. Chronic. Young Scient. 2, 119–125.
2. Dr. Sen (2018). Outside mouth is yummy and inside mouth goes to tummy. World journal of pharmaceutical and life sciences 4(1, 1-04) 1.
3. Fard, M.T., Arulselvan, P., Karthivashan, G., Adam, S.K., Fakurazi, S., 2015. Bioactive extract from Moringa oleifera inhibits the pro-inflammatory mediators in ipopolysaccharide stimulated macrophages. Pharmacog. Mag. 11, S556–S563.
4. Food Safety and Standards Authority of India. (2018). Food Safety and Standards (Fortification of Foods) Regulations, 2018 (Section 16(5)). Retrieved from https://www.fssai.gov.in/upload/uploadfiles/files/Compendium_Food_Fortification_Regulations_30_09_2021
5. Ganguly, R., Guha, D., 2008. Alteration of brain monoamines & EEG wave pattern in rat model of Alzheimer's disease & protection by Moringa oleifera. Ind. J. Med. Res. 128, 744–751.
6. Kumar, S., Pandey, A.K., 2013. Chemistry and biological activities of flavonoids: an overview.Scient. World J. 2013, 162750.
7. Kumar, V., Pandey, N., Mohan, N., Singh, R.P., 2012. Antibacterial & antioxidant activity of different extract of Moringa oleifera leaves–an in-vitro study. Int. J. Pharmacol. Sci. Res. 12, 89-94.
8. Leone A, Bertoli S, Di Lello S, Bassoli A, Ravasenghi S, Borgonovo G, Forlani F, & Battezzati A. (2018). Effect of Moringa oleifera leaf powder on postprandial blood glucose response: In vivo study on Saharawi people living in refugee camps. Nutrients, 10(10), 1-14.
9. Leone A, Spada A, Battezzati A et al (2015) Cultivation, genetic, ethno pharmacology, phytochemistry and pharmacology of Moringa oleifera leaves: an overview. Int J Mol Sci 16:12791–12835.
10. Leone, A., Fiorillo, G., Criscuoli, F., Ravasenghi, S., Santagostini, L., Fico, G., Spadafranca, A., Battezzati, A., Schiraldi, A., Pozzi, F., di Lello, S., Filippini, S., Bertoli, S., 2015a. Nutritional characterization and phenolic profiling of Moringa oleifera leaves grown in Chad, Sahrawi Refugee Camps, and Haiti. Int. J. Mol. Sci. 16, 18923.
11. Mahajan, S.G., Mehta, A.A., 2007. Inhibitory action of ethanolic extract of seeds of Moringa oleifera Lam. on systemic and local anaphylaxis. J. Immunotoxicol. 4, 287–294.
12. Nahar, S., Faisal, F.M., Iqbal, J., Rahman, M., Yusuf, A., 2016. Antiobesity activity of Moringa oleifera leaves against high fat diet-induced obesity in rats. Int. J. Basic Clin. Pharmacol. 5, 1263–1268.
13. Oyeyinka, A. T., & Oyeyinka, S. A. (2018). Moringa oleifera as a food fortificant: Recent trends and prospects. Journal of the Saudi Society of Agricultural Sciences, 17(2), 127-136.
14. Saini R., Saad KR, Ravishankar GA et al (2013) Genetic diversity of commercially grown Moringa oleifera Lam. cultivars from India by RAPD, ISSR and cytochrome P450-based markers. Plant Systematics and Evoluation 299,1205-1213.
15. Satwase, A. N., Pandhre, G. R., Sirsat, P. G., & Wade, Y. R. (2013). Studies on Drying Characteristic and Nutritional Composition of Drumstick Leaves by Using Sun, Shadow, Cabinet and Oven Drying Methods. 2: 584
16. Sharifudin, S.A., Fakurazi, S., Hidayat, M.T., Hairuszah, I., Aris Mohd Moklas, M., Arulselvan, P., 2013. Therapeutic potential of Moringa oleifera extracts against acetaminophen-induced hepatotoxicity in rats. Pharmaceut. Biol. 51, 279–288.
17. Toppo, R., Roy, B.K., Gora, R.H., Baxla, S.L., Kumar, P., 2015. Hepatoprotective activity of Moringa oleifera against cadmium toxicity in rats. Vet. World 8, 537–540.
18. Walter, A., Samuel, W., Peter, A., Jospeh, O., 2011. Antibacterial activity of Moringa oleifera and Moringa stenopetala methanol and n-hexane seed extracts on bacteria implicated in water borne diseases. Afr. J. Microbiol. Res. 5, 153–157.
19. Zakaria, Hadju, V., & Rosmini. (2018). Infant Nutritional Status of 0-6 Months of Exclusive Breastfeed Due to The Application of Moringa Leaf Extract in Breastfeeding Mothers. Health Notions.