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FORMULATION AND FORTIFICATION OF CHICKPEA PASTA WITH BANANA LEAF EXTRACT TO ENHANCE NUTRITIONAL VALUE

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ABSTRACT

The development of functional foods has gained considerable attention due to increasing consumer awareness regarding nutrition and health. Pasta is one of the most widely consumed cereal-based products worldwide; however, conventional pasta primarily serves as a source of carbohydrates and lacks sufficient bioactive compounds. The present study aimed to develop a nutritionally enriched pasta product by incorporating banana leaf extract into chickpea-based pasta and evaluating its phytochemical composition, antioxidant activity, and antimicrobial properties. Fresh banana leaves were subjected to ethanolic extraction and incorporated into pasta dough prepared using chickpea flour and wheat flour. The formulated pasta was analyzed for qualitative phytochemical constituents, antioxidant activity through DPPH radical scavenging assay, superoxide radical scavenging assay, Phosphomolybdenum reduction assay, ferric reducing power assay, and antimicrobial activity against selected bacterial strains. The phytochemical screening revealed the presence of alkaloids, carbohydrates, glycosides, saponins, proteins, amino acids, phenolic compounds, flavonoids, terepenoids, and steroids. Antioxidant activity increased significantly with increasing concentration of the extract. The maximum DPPH radical scavenging activity observed was 37.28 ± 1.04%, while superoxide radical scavenging activity reached 71.74 ± 3.63% at 120 µg/mL concentration. Similarly, Phosphomolybdenum reduction and ferric reducing power assays recorded maximum activities of 74.31 ± 0.64% and 84.25 ± 0.27%, respectively. The results indicate that banana leaf extract possesses significant antioxidant potential and can be effectively incorporated into chickpea pasta to improve its functional and nutritional quality. The developed product may serve as a novel functional food with potential health benefits and commercial applications.

Keywords : Chickpea pasta, Banana leaf extract, Functional food, Antioxidants, Fortification, Phytochemicals, Nutritional enhancement.

1.Introduction :

The modern food industry is increasingly focused on the development of functional foods that provide health benefits beyond basic nutrition. Consumers are becoming more aware of the relationship between diet and health, leading to increased demand for foods enriched with natural bioactive compounds. Functional foods are designed to improve physiological functions, reduce the risk of chronic diseases, and promote overall well-being. The incorporation of natural plant-derived ingredients into commonly consumed food products has emerged as an effective strategy to enhance nutritional quality while maintaining consumer acceptability.

Pasta is among the most popular cereal-based food products consumed globally. Its popularity is attributed to its affordability, convenience, versatility, long shelf life, and ease of preparation. Traditionally, pasta is produced from durum wheat semolina and serves primarily as a carbohydrate-rich food. Although conventional pasta contributes significantly to energy intake, it generally lacks adequate levels of protein, dietary fiber, antioxidants, and other health-promoting compounds. Consequently, researchers have focused on fortifying pasta with nutrient-dense ingredients to improve its nutritional profile and functional properties.

Legumes have attracted considerable attention as ingredients for functional food development due to their high protein content, dietary fiber, vitamins, minerals, and bioactive compounds. Among legumes, chickpea (Cicer arietinum L.) is recognized as one of the most nutritionally valuable pulses. Chickpea contains approximately 20–25% protein, substantial amounts of dietary fiber, and essential minerals such as calcium, iron, magnesium, phosphorus, and zinc. Furthermore, chickpea protein possesses a favorable amino acid profile, making it suitable for improving the nutritional quality of cereal-based products. The incorporation of chickpea flour into pasta formulations has been shown to increase protein content, improve texture, and reduce glycemic response.

Banana (Musa spp.) is one of the most widely cultivated fruit crops worldwide. While the fruit is extensively utilized for human consumption, banana leaves remain an underutilized agricultural by-product despite their abundance and potential nutritional value. Banana leaves contain a variety of phytochemicals, including phenolic compounds, flavonoids, alkaloids, tannins, terepenoids, and saponins. These compounds have been associated with antioxidant, antimicrobial, anti-inflammatory, and therapeutic activities. The presence of these bioactive constituents suggests that banana leaves may serve as a valuable source of functional ingredients for food applications.

Oxidative stress, resulting from an imbalance between free radical production and antioxidant defence systems, has been implicated in the development of numerous chronic diseases, including cardiovascular disorders, diabetes mellitus, neurodegenerative diseases, and certain cancers. Antioxidants play a crucial role in neutralizing free radicals and preventing oxidative damage to biological molecules. Therefore, the incorporation of natural antioxidants into food products has become an important area of research within food science and technology.

The utilization of banana leaf extract in pasta formulation presents multiple advantages. In addition to enhancing antioxidant capacity, it contributes to the sustainable utilization of agricultural residues, thereby reducing environmental waste. Furthermore, the combination of chickpea flour and banana leaf extract offers the possibility of producing a value-added food product with improved nutritional quality and functional properties.

Despite increasing interest in functional pasta products, limited studies have explored the incorporation of banana leaf extract into chickpea-based pasta formulations. Therefore, the present study was undertaken to develop banana leaf extract fortified chickpea pasta and evaluate its phytochemical composition, antioxidant activity, antimicrobial potential, and overall nutritional significance.

2. Material and methods:

2.1. Material:

Fresh banana leaves were collected from local sources in Chennai, Tamil Nadu, India. Chickpea flour, wheat flour, salt, and distilled water were used for pasta preparation. Ethanol was used for extraction of banana leaf bioactive compounds. Analytical grade chemicals including DPPH, ferric chloride, sulfuric acid, sodium phosphate, ammonium molybdate, nitro blue tetrazolium (NBT), riboflavin, EDTA, and ascorbic acid were used for antioxidant analysis. All chemicals and reagents used in the study were of analytical grade

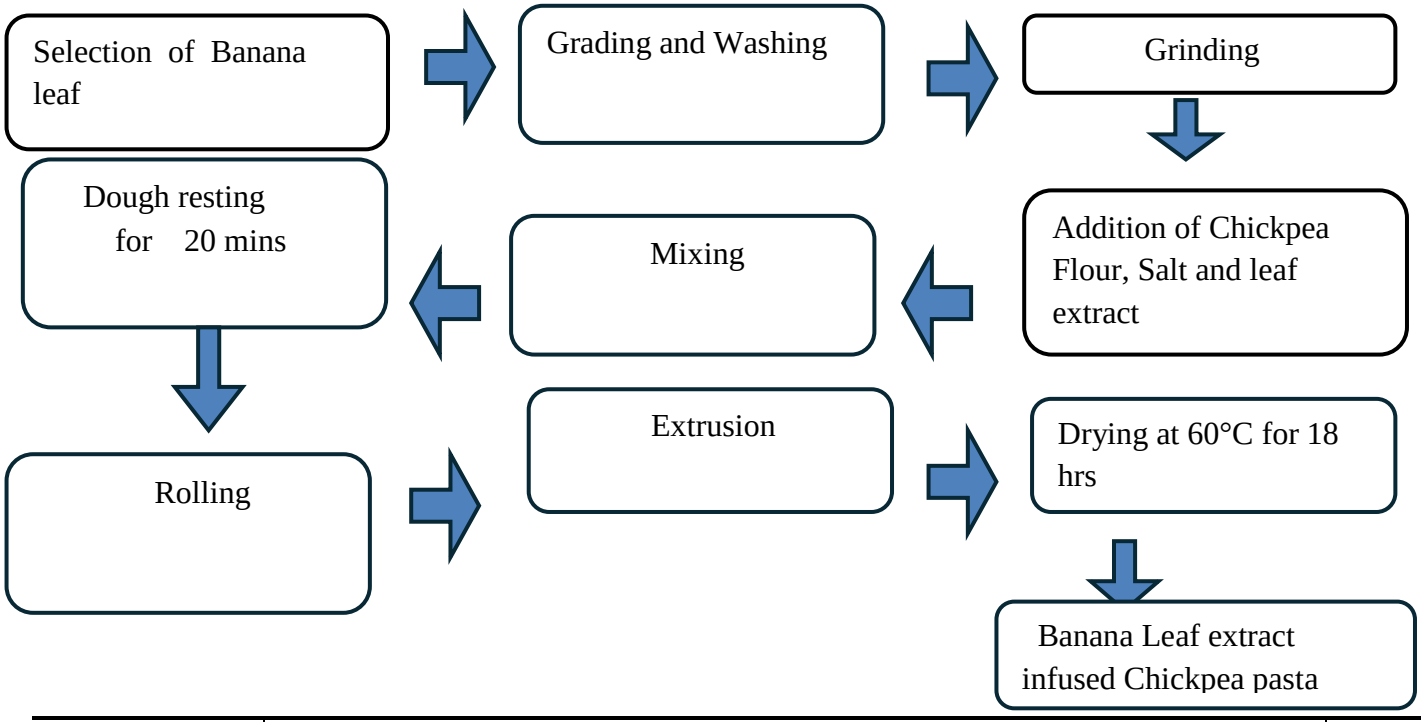
2.2. Preparation of Banana leaf Extract:

Fresh banana leaves were washed thoroughly to remove dust and impurities. Approximately 10 g of leaves were ground into a fine paste and soaked in 100 mL ethanol for 72 hours. The extract was filtered through Whatman filter paper. The filtrate was concentrated at 50°C and stored under refrigerated conditions until further use.

Figure 1: Raw materials used for the preparation of banana leaf extract fortified chickpea pasta.

2.3. Preparation of Chickpea pasta :

Figure 2: Flow chart



2.3.1 Preparation Procedure of Banana Leaf Extract Fortified Chickpea Pasta :

Fresh banana leaves were selected and thoroughly cleaned to remove dirt and impurities. The cleaned leaves were ground into a fine paste and subjected to ethanol extraction to obtain bioactive compounds. The extracted solution was incorporated into a mixture of chickpea flour, wheat flour, and salt. The ingredients were mixed thoroughly to form a uniform dough, which was allowed to rest for 20 minutes. The rested dough was then rolled and extruded into the desired pasta shape. Subsequently, the pasta was dried at 60°C for 18 hours to reduce moisture content and improve shelf stability. The final product obtained was banana leaf extract fortified chickpea pasta, which was further analyzed for phytochemical constituents, antioxidant activity, and antimicrobial properties.

2.4 Phytochemical Screening :

Qualitative phytochemical screening of the banana leaf extract was carried out using standard procedures to identify the presence of alkaloids, carbohydrates, glycosides, saponins, proteins, amino acids, phenolic compounds, flavonoids, terpenoids, and steroids. The appearance of characteristic color changes indicated the presence of the respective phytochemicals.

2.5 Antioxidant Analysis :

2.5.1 DPPH Radical Scavenging Assay :

The antioxidant activity of the extract was evaluated using the DPPH radical scavenging method. Absorbance was measured at 517 nm and the percentage inhibition was calculated.

2.5.2 Superoxide Radical Scavenging Assay :

Superoxide radical scavenging activity was determined using the riboflavin–EDTA–NBT system. Absorbance was measured at 590 nm and scavenging activity was calculated using the above formula.

2.5.3 Phosphomolybdenum Reduction Assay :

Total antioxidant capacity was estimated by Phosphomolybdenum reduction assay. Absorbance was recorded at 695 nm and results were expressed as percentage antioxidant activity.

2.5.4 Ferric Reducing Power Assay :

Ferric reducing power was determined by measuring the reduction of ferric ions to ferrous ions. Absorbance was measured at 700 nm, indicating the reducing capacity of the extract.

2.6 Antimicrobial Activity :

Antimicrobial activity was evaluated using the agar well diffusion method against selected bacterial strains. The test extract was introduced into wells prepared on nutrient agar plates and incubated at 37°C for 24 h. Antimicrobial activity was determined by measuring the diameter of the inhibition zone around each well.

2.7 Statistical Analysis :

All experiments were carried out in triplicate and the results were expressed as mean ± standard deviation. Statistical analysis was performed to evaluate the reliability of the experimental data.

3. Result and Discussion:

3.1. Phytochemical Screening:

The phytochemical analysis confirmed the presence of several bioactive compounds responsible for antioxidant and antimicrobial activities.

S.NO	Phytochemical	Result
1.	Detection of alkaloids	Present
2.	Detection of Carbohydrates	Present
3.	Detection of glucosides	Present
4.	Detection of Saponins	Present
5.	Detection of Proteins	Present
6.	Detection of amino acids	Present
7.	Detection of Phenolic compounds	Present
8.	Detection of flavonoids compounds	Present
9.	Test for terpenoids	Present
10.	Detection of Steroids	Present

Table 1: phytochemical Screening

3.2. Antioxidant Assay:

3.2.1.DPPH Radical Scavenging Activity :

Table 2. DPPH˙ radical scavenging activity of standard (Ascorbic acid) and ethanol extract of banana leaf extract fortified pasta

Ascorbic acid Concentration (µg/ml)	Ascorbic acid (% of inhibition)	Extract Concentration (µg/ml)	Ethanol extract of banana leaf extract (% of inhibition)
2	52.94 ±2.10	20	6.57 ± 2.10
4	58.63± 1.36	40	9.65 ± 1.36
6	64.62±0.72	60	12.71± 0.72
8	66.81± 1.44	80	19.3 ± 1.44
10	68.27±1.02	100	28.95 ± 1.02
12	69.29± 1.04	120	37.28 + 1.04

The DPPH scavenging activity increased with increasing extract concentration, indicating concentration-dependent antioxidant activity. The presence of phenolic compounds and flavonoids may be responsible for this effect.

Figure 3: DPPH Radical Scavenging Activity of Standard (Ascorbic acid)

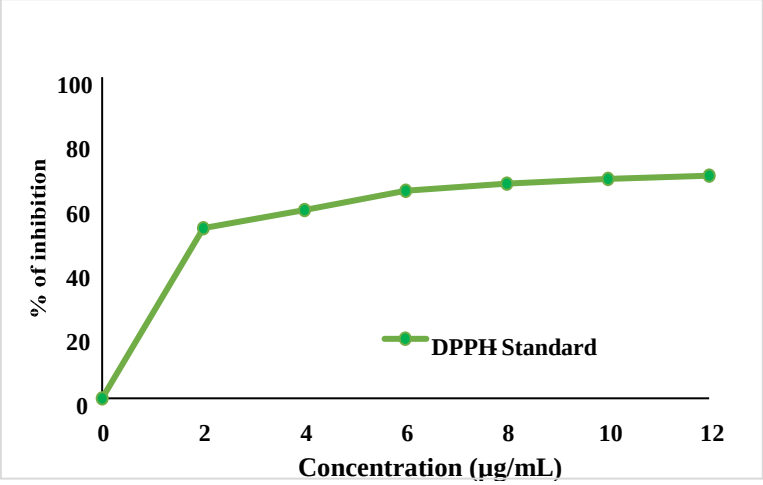
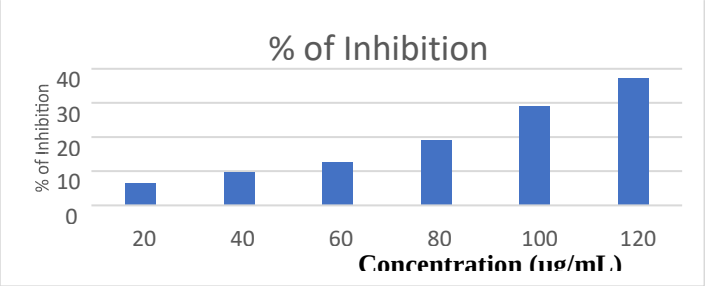


Figure 4: DPPH Radical Scavenging Activity of ethanol extract of banana leaf extract fortified pasta



3.2.2.Superoxide Radical Scavenging Activity :

Table 3**:** Superoxide Radical Scavenging Activity (Ascorbic acid) and ethanol extract of banana leaf extract fortified pasta

Ascorbic acid Concentration (µg/ml)	**Ascorbic acid (%of Inhibition)**	**Extract Concentration (µg/ml)**	**Ethanol extract of banana leaf extract (% of Inhibition)**
2	18.51±4.41	20	32.91±14.88
4	31.72±7.49	40	40.37±12.01
6	47.49±14.54	60	54.34±13.89
8	63.44±14.98	80	61.8±9.58
10	71.41±15.30	100	68.94±4.28
12	79.39±15.67	120	71.74±3.63

The extract showed increasing superoxide radical scavenging activity with increasing concentration. This suggests its potential to neutralize reactive oxygen species.

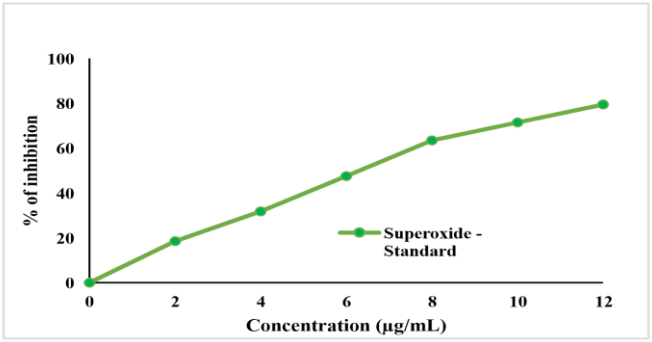
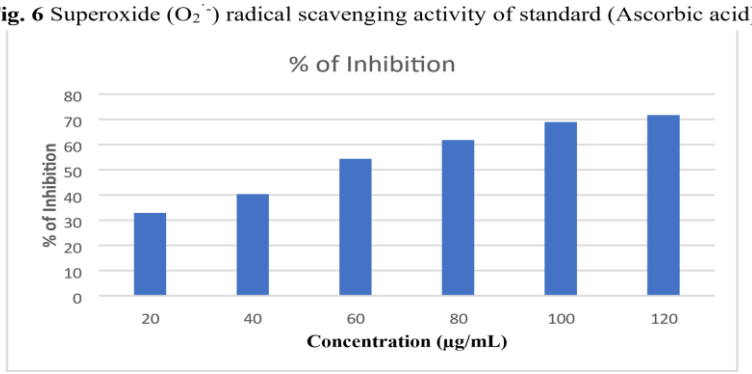


Fig. 6 Superoxide ($O_2^{\cdot-}$) radical scavenging activity of standard (Ascorbic acid)



and ethanol extract of banana leaf extract fortified pasta

3.2.3. Phosphomolybdenum Reduction Assay:

Table 4. Phosphomolybdenum Reduction Activity (Ascorbic acid) and methanol , Chloroform extract of banana leaf extract fortified pasta

Ascorbic acid Concentration (µg/ml)	Ascorbic acid (% of Reduction)	Extract Concentration (µg/ml)	Ethanol extract of banana leaf extract (% of Reduction)
2	**39.54±2.01**	20	**24.113±1.07**
4	**51.63±2.17**	40	**39.89±0.63**
6	**70.27±1.86**	60	**56.5±0.65**
8	**80.52±1.61**	80	**62.59±0.61**
10	**91.47±0.95**	100	**67.28±0.64**
12	**95.96±0.42**	120	**74.31±0.62**

The total antioxidant capacity increased with concentration, indicating good reducing ability of the banana leaf extract. This reflects the presence of natural antioxidant compounds.

Figure 7: Phosphomolybdenum Reduction Activity of Standard (Ascorbic acid)

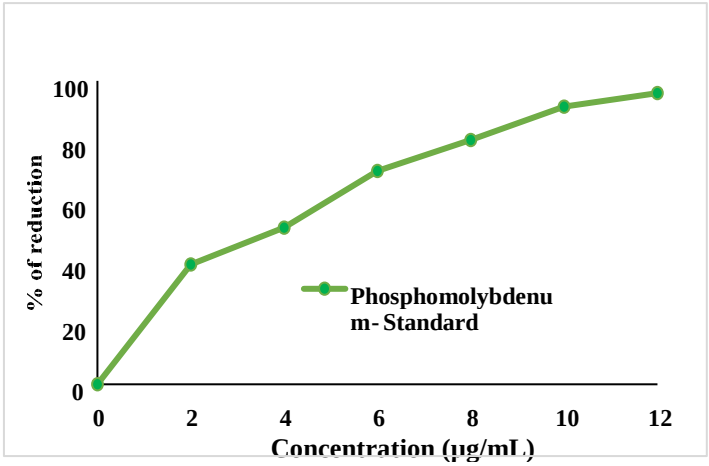
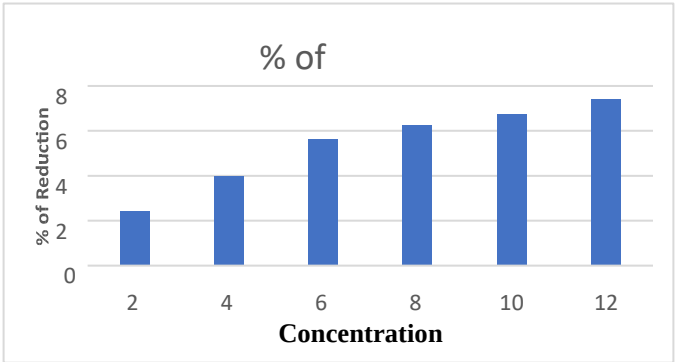


Figure 8: Phosphomolybdenum reduction activity of methanol and chloroform extracts of banana leaf extract fortified Pasta



3.2.4.Ferric (Fe3+) reducing power activity :

Table 5: Ferric (Fe3+) reducing power activity (Ascorbic acid) and ethanol extract of banana leaf extract fortified pasta

Ascorbic acid Concentration (µg/ml)	Ascorbic acid (% of Reduction)	Extract Concentration (µg/ml)	Ethanol extract of banana leaf extract fortified pasta (% of Reduction)
2	42.28 ± 1.02	20	12.73 ± 1.19
4	42.66 ± 1.01	40	41.7 ± 0.48
6	44.33 ± 0.88	60	51.6 ± 0.25
8	61.41 ± 0.52	80	68.46 ± 1.55
10	71.68 ± 0.21	100	782.57 ± 0.94
12	72.26 ± 0.21	120	84.25 ± 0.27

The extract showed increasing superoxide radical scavenging activity with increasing concentration. This suggests its potential to neutralize reactive oxygen species.

Figure 9: Ferric (Fe3+) reducing power activity (Ascorbic acid)

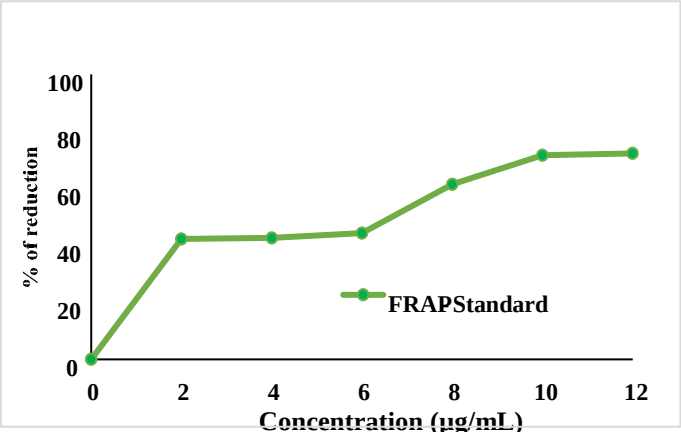
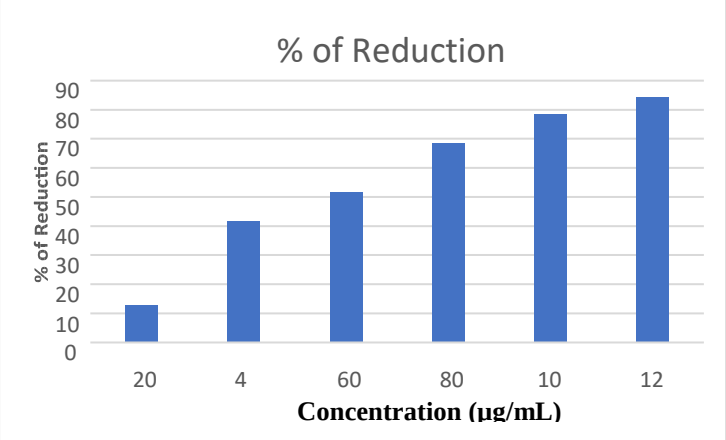


Figure 10 : Ferric (Fe3+) reducing power activity of ethanol extract of banana leaf extract fortified pasta

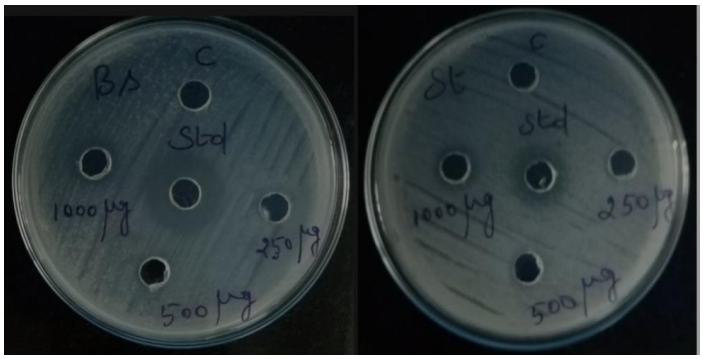


3.3Antimicrobial Activity

Table 6: Antimicrobial Activity

Sample	Bacillus Subtilis	Salmonella typhi
Positive Control	17 mm	14 mm
Pasta	12 mm	12mm

The extract exhibited antimicrobial activity against both Gram-positive and Gram-negative bacteria, suggesting the presence of biologically active phytochemicals.



a) Bacillus Subtilis. B) Salmonella typhi

3.4 Nutritional Composition :

Table 7 : Nutritional Composition of banana leaf extract fortified chickpea pasta

Parameter	Test Method	Unit	Result
Carbohydrates	ALPL/FD/SOP/065	g/100g	57.85
Protein	IS: 7219:1973	g/100g	23.41
Moisture	IS:12711:1989	g/100g	9.71
Ash	IS: 12711:1989	g/100g	2.80
Crude Fibre	IS:10226(Part-1):1982	g/100g	BDL(DL:1.0)

The nutritional composition of banana leaf extract fortified chickpea pasta was determined using standard analytical methods. The results revealed that the developed pasta contained 57.85 g/100 g carbohydrates, 23.41 g/100 g protein, 9.71 g/100 g moisture, and 2.80 g/100 g ash content. The crude fibre content was found to be below the detectable limit. The relatively high protein content may be attributed to the incorporation of chickpea flour, while the ash content indicates the presence of minerals in the fortified product. These findings suggest that banana leaf extract fortified chickpea pasta possesses appreciable nutritional quality and may serve as a potential functional food.

Figure 11: Developed Banana Leaf Extract Fortified chickpea pasta

4. Conclusion

The present study demonstrated the successful development of banana leaf extract fortified chickpea pasta as a functional food product with enhanced nutritional and bioactive properties. Phytochemical screening confirmed the presence of several beneficial compounds, including phenolics, flavonoids, alkaloids, terpenoids, and saponins. The fortified pasta exhibited considerable antioxidant activity in DPPH, superoxide radical scavenging, phosphomolybdenum reduction, and ferric reducing power assays. Antimicrobial studies further revealed inhibitory effects against selected pathogenic microorganisms. The incorporation of banana leaf extract into chickpea pasta not only improved its functional characteristics but also promoted the utilization of underexploited agricultural resources. Therefore, banana leaf extract fortified chickpea pasta may serve as a promising alternative functional food with potential health benefits and commercial applications.

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REFERENCES

1. Prieto, P., Pineda, M., & Aguilar, M. (1999). Spectrophotometric quantitation of antioxidant capacity through the formation of a Phosphomolybdenum complex. Analytical Biochemistry, 269(2), 337–341.
2. Blois, M. S. (1958). Antioxidant determinations by the use of a stable free radical. Nature, 181, 1199–1200.
3. Beauchamp, C., & Fridovich, I. (1971). Superoxide dismutase: Improved assays and an assay applicable to acrylamide gels. Analytical Biochemistry, 44(1), 276–287.
4. Oyaizu, M. (1986). Studies on products of browning reactions: Antioxidative activities of products of browning reaction prepared from glucosamine. Japanese Journal of Nutrition, 44, 307–315.
5. Kubo, I., Muroi, H., & Himejima, M. (1992). Antimicrobial activity of green tea flavor components. Journal of Agricultural and Food Chemistry, 40(2), 245–248.
6. Gulcin, I. (2012). Antioxidant activity of food constituents. Archives of Toxicology, 86, 345–391.
7. Yen, G. C., & Chen, H. Y. (1995). Antioxidant activity of various tea extracts in relation to their antimutagenicity. Journal of Agricultural and Food Chemistry, 43(1), 27–32.
8. Salama, A., et al. (2020). Evaluation of antioxidant properties of plant extracts in food systems. Food Chemistry, 315, 126127.
9. Handayani, D., et al. (2021). Phytochemical composition and antioxidant activity of banana leaves. Food Bioscience, 40, 100875.
10. Mohapatra, D., Mishra, S., & Sutar, N. (2010). Banana and its by-product utilisation. Journal of Scientific and Industrial Research, 69, 323–329.
11. Singh, B., Singh, J. P., Kaur, A., & Singh, N. (2016). Bioactive compounds in banana and their associated health benefits. Food Chemistry, 206, 1–11.
12. Fuad, T., et al. (2010). Quality characteristics of wheat-based pasta products. Food Research International, 43(7), 1782–1788.
13. Giacco, R., et al. (2016). Pasta consumption and healthy dietary patterns. Nutrition Research Reviews, 29(2), 1–12.
14. Shewry, P. R. (2009). Wheat. Journal of Experimental Botany, 60(6), 1537–1553.

15. Jukanti, A. K., Gaur, P. M., Gowda, C. L. L., & Chibbar, R. N. (2012). Nutritional quality and health benefits of chickpea. British Journal of Nutrition, 108(S1), S11–S26.
16. Wood, J. A., & Grusak, M. A. (2007). Nutritional value of chickpea. Plant Foods for Human Nutrition, 62, 189–194.
17. Sánchez-Chino, X., et al. (2015). Chickpea: Nutritional properties and health benefits. Nutrition Hospitalaria, 31(2), 528–535.
18. Hilli, S., et al. (2021). Development of functional pasta enriched with plant-derived ingredients. Journal of Food Science and Technology, 58(4), 1200–1210.
19. Pathare, P. B., et al. (2013). Drying kinetics and quality characteristics of food products. Journal of Food Processing and Preservation, 37(5), 516–528.
20. Brand-Williams, W., Cuvelier, M. E., & Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. LWT – Food Science and Technology, 28(1), 25–30.
21. Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). Analysis of total phenols by means of Folin–Ciocalteu reagent. Methods in Enzymology, 299, 152–178.
22. Sofowora, A. (1993). Medicinal Plants and Traditional Medicine in Africa. Spectrum Books Ltd.
23. Harborne, J. B. (1998). Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. Chapman and Hall.
24. Trease, G. E., & Evans, W. C. (2002). Pharmacognosy (15th ed.). Saunders Publishers.
25. AOAC. (2019). Official Methods of Analysis of AOAC International (21st ed.). AOAC International, Gaithersburg, Maryland, USA.
26. Chemat, F., Vian, M. A., & Cravotto, G. (2012). Green extraction of natural products: Concept and principles. International Journal of Molecular Sciences, 13(7), 8615–8627.
27. Shahidi, F., & Ambigaipalan, P. (2015). Phenolics and polyphenolics in foods, beverages and spices: Antioxidant activity and health effects. Journal of Functional Foods, 18, 820–897.
28. Balasundram, N., Sundram, K., & Samman, S. (2006). Phenolic compounds in plants and their antioxidant activity. Food Chemistry, 99(1), 191–203.
29. Arvanitoyannis, I. S., & Bosnea, L. (2004). Functional foods: A survey of health claims. Critical Reviews in Food Science and Nutrition, 44(5), 385–404.
30. Dewanto, V., Wu, X., Adom, K. K., & Liu, R. H. (2002). Thermal processing enhances antioxidant activity of tomatoes. Journal of Agricultural and Food Chemistry, 50(10), 3010–3014.
31. Siddhuraju, P., & Becker, K. (2003). Antioxidant properties of various solvent extracts of plant materials. Food Chemistry, 81(2), 203–212.
32. Kaur, C., & Kapoor, H. C. (2001). Antioxidants in fruits and vegetables. International Journal of Food Science and Technology, 36(7), 703–725.
33. Espín, J. C., García-Conesa, M. T., & Tomás-Barberán, F. A. (2007). Nutraceuticals: Facts and fiction. Phytochemistry, 68(22–24), 2986–3008.
34. FAO. (2021). The State of Food and Agriculture 2021. Food and Agriculture Organization of the United Nations.
35. AACC International. (2010). Approved Methods of Analysis (11th ed.). AACC International.