Journal of
Food Chemistry & Nanotechnology

https://doi.org/10.17756/jfcn.2025-s1-001

Research Article

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Enhancing Beetroot's Bioactive Compounds for Noodle Incorporation with the Use of Poultry Manure

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Received: January 23, 2025
Accepted: April 28, 2025
Published: May 02, 2025

Citation: Soga K, Mal D, Basin A, Thakur V, Dhaliwal V, et al. 2025. Enhancing Beetroot's Bioactive Compounds for Noodle Incorporation with the Use of Poultry Manure. *J Food Chem Nanotechnol* 11(S1): S1-S7.

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Abstract

The incorporation of functional ingredients into staple foods is gaining momentum as a strategy to improve public health through diet. This study evaluates the effect of poultry manure on the enhancement of bioactive compounds in *Beta vulgaris* (beetroot) and its subsequent use in noodle production. Beetroots were cultivated under different organic manures and the combination of organic manure to assess growth performance, yield, and concentration of key phytochemicals, including betalains, total phenolics, and antioxidant activity. The results indicated that optimal application of poultry manure significantly improved both the yield and bioactive content of beetroot compared to control and chemical fertilizer treatments. Post-harvest, the enriched beetroot was chopped and grinded for fine puree for incorporation into wheat flour at varying substitution levels to develop functional noodles. The substitution level of puree is (0, 5, 10, 15, and 20%) into the wheat flour to enhance the nutritional value of the noodles. Nutritional analysis of the beetroot-fortified noodles revealed enhanced antioxidant potential and higher phenolic content, cooking qualities and sensory evaluation indicated good consumer acceptance in terms of color, texture, and taste, particularly at lower substitution levels. This study demonstrates that poultry manure not only serves as an eco-friendly alternative to chemical fertilizers but also boosts the nutritional quality of crops, making them suitable for functional food development. The integration of organically enriched beetroot into noodles presents a promising approach to sustainable agriculture and value-added food innovation.

Keywords

Beetroot, Poultry manure, Bioactive compounds, Functional noodles, Organic agriculture, Antioxidants, Food fortification

Introduction

In today's world, consumers worldwide are increasingly sensitive to many diseases, including diabetes, as a result of obesity, high cholesterol, cardiovascular diseases, high blood pressure, and irregular blood sugar levels. The growing awareness about the importance of functional foods, which offer both nutritional and health benefits, has driven interest in agricultural practices that enhance the bioactive compounds in crops [1]. These risk factors arise due to an inadequate diet that is deficient in essential vitamins and minerals such as dietary fiber, phytochemicals, and antioxidants [2]. Due to its rich nutrient profile, beetroot has gained considerable attention as a key ingredient for functional food products, including noodles, which are a staple in many diets worldwide [3].

Beetroot (*B. vulgaris* L.) is a root vegetable that is known to be beneficial for health. This is because it contains important substances such as vitamins, minerals, phenolics, carotenoids, nitrates, and betalains. The bioactive compounds

found in beetroot include antioxidant, anti-inflammatory, anticarcinogenic, hepatoprotective, antidiabetic, cholesterol-lowering, and wound-healing properties. However, conventional farming practices in the country have excessively depended on artificial fertilizers, pesticides, and herbicides, resulting in soil deterioration, water contamination, and adverse effects on the health of humans [4]. Therefore, it is essential to shift towards more sustainable and environmentally friendly farming practices [5]. Agricultural practices have a direct influence on the biochemical composition and nutritional quality of crops. Organic fertilizers, such as poultry manure, are increasingly being promoted as sustainable alternatives to synthetic fertilizers. Poultry manure is a nutrient-dense organic fertilizer rich in nitrogen, phosphorus, and potassium, along with essential micronutrients that support plant growth and development. When used in crop production, poultry manure not only improves soil fertility and plant productivity but may also influence the biochemical composition and the levels of bioactive compounds in crops such as beetroots. Not only the poultry manure other organic fertilizers, such as compost, manure and neem cake, are crucial elements of organic agriculture due to their capacity to improve soil fertility, increase nutrient availability, promote beneficial soil organisms, and increase crop production [6]. Recently, numerous studies have investigated the potential of organic farming as an alternate method to enhance agricultural sustainability [7].

Noodles belong to a class of cereal-based foods and are usually made from wheat. The two main traditional staple foods in China are wheat and rice. However, these foods have several limitations such as having a similar nutritional composition, insufficient nutrition, and high calorie content [8]. Incorporating beetroot into noodles presents a unique opportunity to enhance the nutritional and functional properties of this widely consumed food product. The worldwide consumption and usage of this product is favored by its cooking convenience, inexpensive cost, long shelf life, variety, desired sensory properties, palatability, and interesting flavor. The annual global consumption of instant noodles is estimated to be around 103 billion packets. The nutritional composition of noodles primarily derives from flour, as flour serves as the primary ingredient in noodle production. Noodles may contain carbohydrates, proteins, a small amount of fat, and small quantities of minerals. The noodles have a carbohydrate content of 75%, protein content ranging from (11% - 15%), and a fat content of 0.6%. However, the noodles are deficient in various micronutrients and dietary fiber [9].

Usually, instant noodles are prepared with wheat flour that has a low protein and dietary fiber content [10]. Wheat flour noodles can be replaced with various substances to increase their fiber and protein content. By incorporating beetroot, which is rich in vitamins, minerals, and bioactive compounds, into noodles, it is possible to create a functional food product with improved health benefits. Thus, noodles can also be eaten as a complete meal to fulfil nutritional needs of the human body [11]. In simple terms, food that satisfies the requirements of "health, safety, and nutrition" is more likely to become a new essential food [12].

The main research challenge examined in this study was the absence of comprehensive information on the productivity of beetroot farming when utilizing organic fertilizer. As a result, farmers may be unwilling to switch from using synthetic fertilizer to using organic fertilizer because of uncertainties about its effectiveness and economic viability. The primary objective of this study was to analyze data pertaining to the production of beetroot crops when organic manure is utilized as a fertilizer. However, it is crucial to do more research that incorporates data regarding the soil's state before the utilization of organic manures, the nutrient levels before implementation, and the prevailing meteorological conditions during the experiment. The absence of such information is seen as a constraint of the study.

According to the 17 sustainable development goal (SDG-17) approved by all the United Nations Members States, today's food industry and agri-food research have placed a major priority on the reduction of industrial waste in the production of fruits and vegetables. The task can be accomplished through either the valorizing of agri-food by-products or through the improvement of food production technologies. By applying effective stabilization procedures and extraction methods, the process of improving nutritional composition of food by-products is a valuable opportunity to promote the sustainable development of the sector, while simultaneously providing economic and social benefits to the general population [13].

One barrier to implementing this technique is the fact that teens often dislike vegetables. Vegetables have been recognized for their beneficial effects on health, but they rarely appeal to young people and adolescents because of their bitterness, undesirable texture, and their low satiating capacity [14]. An effective strategy to enhance children's vegetable consumption is to include vegetables into a food matrix that corresponds to their preferences. Multiple studies have demonstrated that children highly value noodles, making them an excellent choice to manufacture vegetable enrich food products.

This study aims to investigate the effect of poultry manure on the biochemical and nutritional properties, as well as the bioactive compound content, of beetroot when incorporated into noodles. Specifically, the study will assess how poultry manure influences key biochemical markers such as total phenolic content, antioxidant activity, and betalain concentration in beetroot. Additionally, the study will explore the nutritional composition of beetroot noodles, including macronutrient and micronutrient content, as well as evaluating the sensory properties of the final product.

By understanding the impact of organic fertilization on beetroot's bioactive compounds and nutritional profile, this research aims to contribute valuable insights into the development of functional foods with enhanced health benefits. The findings of this study will not only provide a foundation for optimizing agricultural practices to improve crop quality but also offer practical solutions for incorporating nutrient-rich ingredients like beetroot into everyday food products such as noodles, thereby promoting healthier dietary options for consumers.

Materials and Methods

Preparation of beetroot puree (BP)

Fresh, mature beetroot (*B. vulgaris*) roots were collected from the organically managed experimental plots at Lovely Professional University (LPU), Punjab, India. After harvesting, the beets were thoroughly washed with clean tap water to remove soil, followed by rinsing with distilled water to eliminate surface impurities. The cleaned beetroots were then peeled manually using a stainless-steel knife to reduce enzymatic browning and contamination. The peeled roots were cut into uniform cubes (approximately 1 - 2 cm in size) to ensure even cooking. The beetroot cubes were steam-cooked for 10 - 15 min until soft, taking care to preserve the nutritional and phytochemical content by avoiding direct boiling. After cooling to room temperature, the cooked beet pieces were homogenized using a high-speed food-grade blender to obtain a smooth, lump-free puree. No additional water, preservatives, or additives were used during the preparation process to maintain the natural integrity of the sample. The BP was either used immediately in subsequent experimental procedures or stored in sterilized, airtight food-grade containers at 4 ± 1 °C for not more than 24 h to preserve its color, nutritional value, and microbial safety (Figure 1).



Figure 1: Preparation of BP.

Formulation of the noodles incorporated with BP

The most important steps in the production of noodles are the weighing of the raw material, the mixing of the ingredients, the resting, the sheeting, and the cutting [15]. The wheat flour and BP with the different quantities (5, 10, 15, and 20 gm) and combined with starch, were placed in a kneader and allowed to idle for 5 min to ensure that the water was equally distributed when the compounding water was added to raw materials. The refined salt was fully dissolved in water and uniformly sprayed to prevent the formation of lumps of the raw materials. After 15 min of kneading, the dough was subsequently rolled using a noodle making machine. The rolling operation was repeated multiple times to gradually reduce the thickness of the mixture.

During the rolling procedures, the gluten in the wheat flour becomes more active, causing all of its raw materials to come together and ultimately produce the noodle sheet. After multiple rolling processes, the sheet was placed on the noodle making machine and made a cut at the length of 20 mm. The control noodle was made with wheat flour only [16].

Biochemical properties of the noodles incorporated with BP

All the chemicals utilised in the current investigation were of analytical grade. The proximate composition, including moisture, crude fat, crude protein, total ash, and fiber, was analyzed using the AOAC (2000) method in the research paper [17]. The total carbohydrate was calculated by subtracting the sum of moisture, protein, fat and ash from 100.

Phytochemical parameters of the noodles incorporated with BP

Raw BP and noodle samples were analyzed for the antioxidant activity was measured using the percent inhibition of the 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) method, while the aluminum chloride colorimetric method was used to estimate flavonoid content. Total phenols were assessed with the Folin-Ciocalteu reagent method, as described [18], with minor modifications. Total betalains, including betaxanthins and betacyanin's, were quantified in BP and noodles using spectrophotometric measurements at 538 nm and 480 nm [19].

Functional characteristics of noodles

Gluten percentage

The gluten content in a sample of flour can be determined by hydrating the flour with water and subsequently removing starch, sugars, water-soluble proteins, and other minor components from the dough. The wet cohesive, viscoelastic substance obtained is known as wet gluten, whereas the dehydrated product derived from it is known as dry gluten.

$$\text{Wet gluten (\%)} = \frac{W2 - W1}{25} \times 100$$

$$\text{Dry gluten (\%)} = \frac{W3 - W1}{25} \times 100$$

Water absorption (WA)

The WA was estimated using the ratio of the total weight of cooked noodles to the weight of noodles before cooking, as outlined in the AACC method.

$$WA(\%) = \frac{Weight\ of\ cooked\ noodlles - weight\ of\ raw\ noodles}{Weight\ of\ raw\ noodles} \times 100$$

Sensory evaluation

Process of assessing and analyzing the sensory properties of a product using human senses such as taste, smell, sight,

touch, and hearing. The sensory evaluation was conducted using the triangle test, which involved administering a questionnaire to a panel of members. The purpose of the study was to assess the color, appearance, flavor, taste, and general acceptability of the product. A hedonic scale ranging from 1 to 9 was employed, with 1 representing severe negativity and 9 representing exceptional positivity [20]. The scale was defined as follows: 1: extremely bad, 2: unbelievably bad, 3: bad, 4: fairly bad, 5: satisfactory, 6: fairly good, 7: good, 8: very good, and 9: excellent. The higher rating indicated good quality attributes.

Results and Discussion

Proximate composition of BP incorporated noodles

BP incorporated noodles were analyzed for nutritional characteristics along with the control sample. On increase in incorporation of BP (0 - 20%), there was significant variation in moisture from 4.43 ± 0.312 to 5.98 ± 0.09%, protein from 12.09 ± 0.081 to 10.92 ± 0.29%, fat from 13.13 ± 0.015 to 16.11 ± 0.23%, ash from 0.99 ± 0.03 to 2.03 ± 0.04%, crude fiber from 0.73 ± 0.09 to 1.95 ± 0.017%, nutrient free extract (NFE %) from 61.85 ± 0.158 to 69.80 ± 0.31 %, and Calorific value from 440.71 ± 0.358 to 443.57 ± 0.456%. Overall, low moisture content typically extends the shelf life of food products. The small rise in moisture was accompanied by a notable reduction in protein content, resulting from the substitution of flour with BP. Protein content is crucial as it affects the cooking quality of the product. As the level of BP in the treatment increases, there is a notable improvement in the nutritional quality of the noodles, particularly in terms of crude protein, crude fat, fiber, and ash as represented in table 1. Comparable findings were reported by Adebowale et al. [21], supporting the observed increase in protein and fiber content in beetroot-incorporated noodles. The relatively stable caloric value, despite the nutritional enhancement, suggests that these noodles may serve as a more balanced dietary option, particularly for health-conscious consumers seeking higher protein and fiber intake. An increase in fat content was also noted in the beetroot-enriched noodles, which may be attributed to the higher moisture content of the puree and the resulting increased fat uptake during frying. Moisture loss during frying leads to the formation of microscopic pores, facilitating oil absorption through capillary action. Similar results were observed by Wang et al. [22] in noodles incorporated with northern beans. Proximate composition analysis further confirmed that beetroot exhibited the highest protein and carbohydrate levels among the evaluated vegetables. These findings are consistent with those of Jahan et al. [23], who reported that beetroot is a rich source of essential nutrients, including dietary fiber, vitamins, protein, carbohydrates, and minerals.

Phytochemical analysis of BP incorporated noodles

Phyto constituents contribute to attractive color, higher phytochemical compound has potential to enhance the overall acceptability (OA). Beetroot addition significantly improved ($p < 0.05$) the total phenol (62.17 ± 0.055 to 138.51 ± 0.0181 GAE mg/100 g), flavonoids (3.33 ± 0.233 to 13.83 ± 0.0.31 QE mg/100 g), betaxanthin (0.00 ± 0.00 to 27.37 ± 0.031 mg/100 g), betacyanin (0.00 ± 0.00 to 68.75 ± 0.3 mg/100 g), and betalains content (0.00 ± 0.00 to 96.12 ± 0.044 mg/100 g) in noodles (Table 2). The observed increase in bioactive compounds can be attributed to the higher concentration of phytochemical-rich BP incorporated into the noodle formulation. As anticipated, the addition of BP significantly enhanced the

Table 1: Proximate analysis of noodles incorporated with BP.

	Moisture %	Crude protein %	Crude fat %	Ash content %	Crude fibre %	NFE %	Calorific value
T0 (Control)	4.423 ± 0.312^{b}	10.92 ± 0.029^{c}	13.12 ± 0.015^{d}	0.99 ± 0.03^{d}	0.73 ± 0.009^{d}	69.79 ± 0.316	441.02 ± 1.242^{a}
T1 (95:5)	4.68 ± 0.225^{ab}	11.03 ± 0.044^{c}	13.92 ± 0.032^{c}	1.18 ± 0.02^{c}	0.94 ± 0.015^{c}	68.23 ± 0.277^{a}	442.37 ± 0.82^{a}
T2 (90:10)	4.93 ± 0.073^{ab}	11.23 ± 0.059^{b}	14.82 ± 0.025^{b}	1.52 ± 0.036^{b}	1.18 ± 0.015^{b}	66.31 ± 0.135^{b}	443.56 ± 0.456^{a}
T3 (85:15)	5.14 ± 0.105^{a}	11.95 ± 0.081^{a}	15.03 ± 0.038^{a}	1.94 ± 0.015^{a}	1.41 ± 0.007^{a}	64.51 ± 0.077^{c}	441.18 ± 0.592^{a}
T4 (80:20)	5.97 ± 0.088	12.08 ± 0.081^{a}	16.1 ± 0.023	2.03 ± 0.04^{a}	1.95 ± 0.017	61.85 ± 0.158^{d}	440.7 ± 0.358^{a}

Note: Means in the column having different superscripts are significantly different at $p \leq 0.05$. T0 = control noodles with wheat flour only; T1 = noodles with 100 g wheat flour, 5 g beetroot pulp; T2 = noodles with 100 g wheat flour, 10 g BP; T3 = noodles with 100 g wheat flour, 15 g BP; and T4 = noodles with 100 g wheat flour, 20 g BP.

Table 2: Phytochemical properties of the noodles incorporated with BP.

	Total phenolic content	Total flavonoid contents	Betaxanthin	Betacyanin	Betalains
T0 (Control)	62.07 ± 0.055	3.32 ± 0.233	0 ± 0.00	0 ± 0.00	0 ± 0.00
T1 (95:5)	84.19 ± 0.13	7.91 ± 0.431	21.53 ± 0.065	57.62 ± 0.015	79.15 ± 0.078
T2 (90:10)	110.36 ± 0.368	8.19 ± 0.093	23.23 ± 0.36	59.24 ± 0.02	82.47 ± 0.356
T3 (85:15)	125.39 ± 0.099	11.24 ± 0.031	26.59 ± 0.043	62.53 ± 0.022	89.13 ± 0.055
T4 (80:20)	138.50 ± 0.018	13.83 ± 0.031	27.37 ± 0.025	68.74 ± 0.026	96.11 ± 0.044

Note: Means in the column having different superscripts are significantly different at $p \leq 0.05$. T0 = control noodles with wheat flour only; T1 = noodles with 100 g wheat flour, 5 g BP; T2 = noodles with 100 g wheat flour, 10 g BP; T3 = noodles with 100 g wheat flour, 15 g BP; and T4 = noodles with 100 g wheat flour, 20 g BP.

levels of phenolic compounds and betalains in the noodles, as reported by Mohammed et al. [24]. Betalains, responsible for the characteristic deep red-violet hue of beetroot, impart a vibrant and visually appealing color to the noodles, which may improve consumer acceptability. These pigments also serve as natural indicators of freshness and quality, as they are sensitive to degradation under heat, light, and pH fluctuations. Similar observations regarding betalain-enhanced food products have been reported by Guldiken et al. [25]. Among the various bioactive compounds present, BP is particularly rich in total phenols and betalains. In addition, beetroot contains a wide array of health-promoting constituents, including betaine, betaxanthin, ascorbic acid, rutin, epicatechin, folate, and other phenolic and flavonoid compounds, all of which contribute to its antioxidant and radical-scavenging potential [26]. These compounds play a crucial role in mitigating oxidative stress and may offer protective health benefits. The findings of this study clearly demonstrate a substantial improvement in the nutritional and functional quality of noodles fortified with BP, confirming its potential as an effective vehicle for delivering flavonoids, phenolic compounds, betacyanin, and other valuable bioactive. Thus, BP serves as a promising natural ingredient for the development of nutrient-dense, functional noodle products.

Cooking properties of the BP incorporated noodles

The results of gluten content of wheat flour were shown in figure 2, for wet gluten and dry gluten of wheat flour was 32 ± 0.01% and 22 ± 0.3%, respectively. These results were higher than that reported by Chinese [27] who concluded that dry gluten from different cultivars of hard wheat ranged between 9 to 11%. Gluten can be defined as a composite of storage proteins termed prolamins and glutelin's and stored together with starch in the endosperm (which nourishes the embryonic plant during germination) of various grass-related grains. Gluten is found in wheat, barley, rye, and oats [28] related species and hybrids like spelt, Khorasan, emmer, einkorn, triticale, kamut, etc.) and products of these such as malt. Gluten is appreciated for its viscoelastic properties. It gives elasticity to dough, helping it rise and keeps its shape and often gives the final product a chewy texture.

Cooking quality in terms of cooking time, cooked weight is a significant parameter in defining noodle quality by consumers and are represented in figure 2. Addition of BP in noodles progressively increased cooking time due to lower rate of WA as there is competition between protein (gluten), starch granules and fibers for absorption of water. Fiber restricted starch granules leaching, hinder the entry of water in granules thus increasing the gelatinization temperature and cooking time. Comparable results have been reported [29].

WA of the noodle samples slightly decreased from 2.95 ± 0.05 to 2.68 ± 0.31 g/g as the substitution of BP increased from 0% to 20%. As shown in figure 2, a slight reduction in WA was observed when the noodles were fortified with BP. Similar findings were reported by Chen et al. [30], who suggested that wheat bran affects water transport due to its self-absorption properties. In this study, we conclude that the self-absorption capacity of dietary fiber from BP likely influenced water diffusion during cooking. The enhanced water solubility in noodles formulated with 20% BP can be attributed to the elevated dietary fiber content, which disrupts gluten network formation. This disruption in the gluten matrix likely weakens the structure, resulting in increased leaching of solids during cooking, as reported by Ma et al. [31], Kaur et al. [32], and Bustos et al. [33].

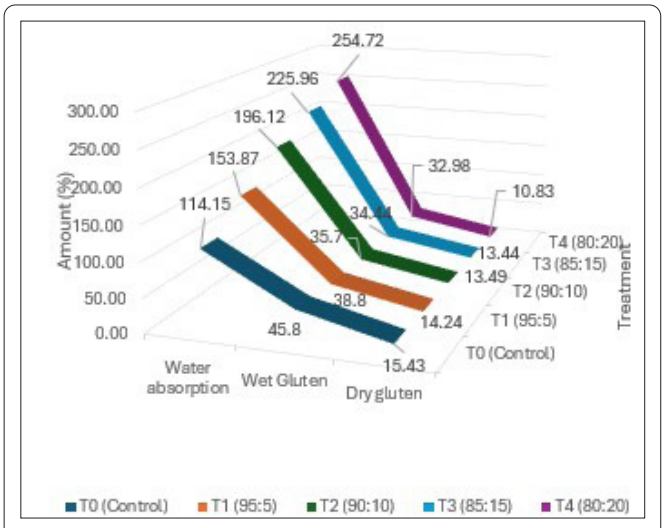


Figure 2: Cooking properties of the noodles incorporated with BP.

Organoleptic evaluation of noodles incorporated with BP

The noodles were developed with varying levels of BP supplementation: T0 (0% BP), T1 (5%), T2 (10%), T3 (15%), and T4 (20%), where refined wheat flour was replaced by BP in each formulation. Sensory evaluation was performed to assess the appearance, flavor, taste, texture, and OA of the resulting noodles. The data revealed that noodles with 20% BP (T4) exhibited significantly lower scores in appearance (6.34 ± 0.29), texture (5.62 ± 0.328), and OA (5.57 ± 0.166). The poor sensory outcomes of the T4 noodles can be attributed to their darker color and higher solid loss during cooking, which resulted in undesirable textural properties. These findings are consistent with previous studies, which indicate that excessive incorporation of BP can compromise the textural characteristics of noodle products due to increased moisture content and the disruption of the gluten network [21]. In contrast, the noodles with 15% BP (T3) achieved the highest sensory scores for appearance (8.47 ± 0.24), flavor (8.13 ± 0.258), taste (8.83 ± 0.41), texture (8.63 ± 0.088), and OA (8.52 ± 0.197), as shown in figure 3. The improved sensory qualities observed in T3 can be attributed to an optimal balance between the BP and wheat

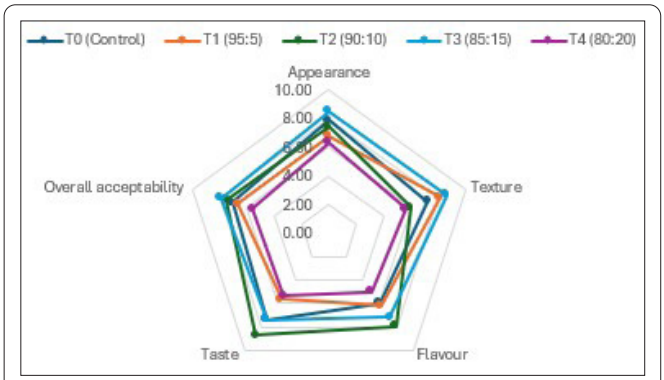


Figure 3: Organoleptic properties of the noodles incorporated with BP.

flour, which enriched the noodles with bioactive compounds such as betalains and dietary fiber while preserving structural integrity and texture. These results are in line with findings from earlier studies, which suggest that a moderate incorporation of BP, such as 15%, provides the ideal formulation for enhancing nutritional value without compromising the functional and sensory qualities of noodles [22-24]. Thus, the 15% BP formulation emerges as the most acceptable and nutritionally enhanced noodle product in this study.

Conclusion

This study demonstrates that incorporating BP into noodles enhances their bioactive compounds, such as phenolics, betalains, and dietary fiber, with poultry manure proving effective in boosting beetroot growth and nutritional content. The 15% BP formulation yielded the best sensory qualities, including appearance, flavor, and texture, while higher concentrations (20%) led to reduced sensory acceptance. The results highlight the potential of beetroot-enriched noodles as a nutritious alternative to traditional noodles, offering added health benefits like antioxidant properties and improved fiber intake. Additionally, the use of poultry manure presents an eco-friendly and cost-effective method for enriching food products. Future research should focus on further optimizing the formulation and assessing the health benefits and consumer acceptance of these enhanced noodles.

Acknowledgements

I would like to express my sincere gratitude to the Department of Horticulture, School of Agriculture and Department of Food Science and nutrition of the LPU, Phagwara, Punjab. For invaluable guidance and support throughout this research on the "Enhancing Beetroot's Bioactive Compounds for Noodle Incorporation with the Use of Poultry Manure". I am also thankful to the faculty and staff of LPU for providing the necessary resources and facilities, as well as to the farmers who assisted in the cultivation of beetroot and poultry manure.

Conflict of Interest

None.

References

1. Watson RR, Preedy VR. 2009. Bioactive Foods in Promoting Health: Fruits and Vegetables. Academic Press.
2. Oyegoke RA, Oladele JO, Oladele OT, Oladiji AT. 2024. Role of dietary fibre and phytonutrients in human health and nutrition. In Nutrition and Diet in Health. CRC Press, pp 121-147.
3. Bangar SP, Singh A, Chaudhary V, Sharma N, Lorenzo JM. 2023. Beetroot as a novel ingredient for its versatile food applications. *Crit Rev Food Sci Nutr* 63(26): 8403-8427. https://doi.org/10.1080/10408398.2022.2055529
4. Sarkar S, Jaswal A, Singh A. 2024. Sources of inorganic nonmetallic contaminants (synthetic fertilizers, pesticides) in agricultural soil and their impacts on the adjacent ecosystems. In Bioremediation of Emerging Contaminants from Soils. Elsevier, pp 135-161.
5. Bhagat R, Walia SS, Sharma K, Singh R, Singh G, et al. 2024. The integrated farming system is an environmentally friendly and cost-effective approach to the sustainability of agri-food systems in the modern era of the changing climate: a comprehensive review. *Food Energy Secur* 13(1): e534. https://doi.org/10.1002/fes3.534
6. Liu Y, Lan X, Hou H, Ji J, Liu X, et al. 2024. Multifaceted ability of organic fertilizers to improve crop productivity and abiotic stress tolerance: review and perspectives. *Agronomy* 14(6): 1141. https://doi.org/10.3390/agronomy14061141
7. Calabro G, Vieri S. 2024. Limits and potential of organic farming towards a more sustainable European agri-food system. *Br Food J* 126(1): 223-236. https://doi.org/10.1108/BFJ-12-2022-1067
8. Ding Y, Wang J, Sun L, Zhou X, Cheng J, et al. 2021. Effect of kansui on the physicochemical, structural, and quality characteristics of adlay seed flour-fortified wheat noodles. Lwt 146: 111458. https://doi.org/10.1016/j.lwt.2021.111458
9. Zhang N, Ma G. 2016. Noodles, traditionally and today. *J Ethn Foods* 3(3): 209-212. https://doi.org/10.1016/j.jef.2016.08.003
10. Yadav S, Gupta RK. 2015. Formulation of noodles using apple pomace and evaluation of its phytochemicals and antioxidant activity. *J Pharmacogn Phytochem* 4(1): 99-106.
11. Qing TY. 2017. Shelf Life Study of Homemade Noodles Incorporated with Bell pepper (*Capsicum* sp.).
12. Yingmei W, Wu Y, Xu L, Yu Y, Wang C, et al. 2024. Effects of coix seed on physicochemical, structural and digestive properties of wheat dough and noodle quality. Structural and digestive properties of wheat dough and noodle quality.
13. Sarfraz M, Iqbal K, Wang Y, Bhutta MS. 2023. Role of agricultural resource sector in environmental emissions and its explicit relationship with sustainable development: evidence from agri-food system in China. *Resour Policy* 80: 103191. https://doi.org/10.1016/j.resourpol.2022.103191
14. Shere PD, Devkatte AN, Pawar VN. 2018. Studies on production of functional noodles with incorporation of spinach puree. *Int J Curr Microbiol App Sci* 7(6): 1618-1628. https://doi.org/10.20546/ijcmas.2018.706.193
15. Hou GG. 2020. Processing technology of wheat flour noodle. In Asian Noodle Manufacturing. Woodhead Publishing, pp 43-62.
16. Kang J, Lee J, Choi M, Jin Y, Chang D, et al. 2017. Physicochemical and textural properties of noodles prepared from different potato varieties. *Prev Nutr Food Sci* 22(3): 246-250. https://doi.org/10.3746/pnf.2017.22.3.246
17. Nielsen SS. 2024. Introduction to Food Analysis. In Nielsen's Food Analysis. Springer International Publishing, pp 3-14.
18. Sęczyk Ł, Świeca M, Gawlik-Dziki U. 2016. Effect of carob (*Ceratonia siliqua* L.) flour on the antioxidant potential, nutritional quality, and sensory characteristics of fortified durum wheat pasta. *Food Chem* 194: 637-642. https://doi.org/10.1016/j.foodchem.2015.08.086
19. Ravichandran K, Saw NM, Mohdaly AA, Gabr AM, Kastell A, et al. 2013. Impact of processing of red beet on betalain content and antioxidant activity. *Food Res Int* 50(2): 670-675. https://doi.org/10.1016/j.foodres.2011.07.002
20. Abdo EM, Shaltout OE, El-Sohaimy S, Abdalla AE, Zeitoun AM. 2021. Effect of functional beetroot pomace biscuit on phenylhydrazine induced anemia in albino rats: hematological and blood biochemical analysis. *J Funct Foods* 78: 104385. https://doi.org/10.1016/j.jff.2021.104385
21. Adebowale OJ, Salaam HA, Komolafe OM, Adebiyi TA, Ilesanmi IO. 2017. Quality characteristics of noodles produced from wheat flour and modified starch of African breadfruit (*Artocarpus altilis*) blends. *J Culin Sci Technol* 15(1): 75-88. https://doi.org/10.1080/15428052.2016.1204973
22. Wang H, Ratnayake WS. 2016. Great Northern bean could improve the nutritional value of instant noodles. *Cereal Chem* 93(2): 156-161. https://doi.org/10.1094/CCHEM-06-15-0133-R
23. Jahan R, Polash MA, Karim MM, Juthee SA, Fakir MS, et al. 2021. Extraction, characterization and biochemical analysis of betacyanins

derived from beetroot (*Beta vulgaris*). *Res Crops* 22(1): 216-223. http://dx.doi.org/10.31830/2348-7542.2021.060

24. Mohammed EA, Abdalla IG, Alfawaz MA, Mohammed MA, Al Maiman SA, et al. 2022. Effects of extraction solvents on the total phenolic content, total flavonoid content, and antioxidant activity in the aerial part of root vegetables. *Agriculture* 12(11): 1820. https://doi.org/10.3390/agriculture12111820
25. Guldiken B, Toydemir G, Nur Memis K, Okur S, Boyacioglu D, et al. 2016. Home-processed red beetroot (*Beta vulgaris* L.) products: changes in antioxidant properties and bioaccessibility. *Int J Mol Sci* 17(6): 858. https://doi.org/10.3390/ijms17060858
26. Bastos EL, Schliemann W. 2022. Betalains as Antioxidants. In Plant Antioxidants and Health. Springer International Publishing, pp 51-93.
27. Chinese J. 2018. Production of noodles from composite flour and it is nutritional and sensory characteristics. *Chinese J Med Res* 1(1): 3-7.
28. Volta U, Caio G, De Giorgio R, Henriksen C, Skodje G, et al. 2015. Non-celiac gluten sensitivity: a work-in-progress entity in the spectrum of wheat-related disorders. *Best Pract Res Clin Gastroenterol* 29(3): 477-491. https://doi.org/10.1016/j.bpg.2015.04.006
29. DePilli T, Derossi A, Severini C. 2013. Cooking quality characterisation of 'spaghetti' based on soft wheat flour enriched with oat flour. *Int J Food Sci Technol* 48(11): 2348-2355. https://doi.org/10.1111/ijfs.12224
30. Chen JS, Fei MJ, Shi CL, Tian JC, Sun CL, et al. 2011. Effect of particle size and addition level of wheat bran on quality of dry white Chinese noodles. *J Cereal Sci* 53(2): 217-224. https://doi.org/10.1016/j.jcs.2010.12.005
31. Ma S, Wang Z, Liu N, Zhou P, Bao Q, et al. 2021. Effect of wheat bran dietary fibre on the rheological properties of dough during fermentation and Chinese steamed bread quality. *Int J Food Sci Technol* 56(4): 1623-1630. https://doi.org/10.1111/ijfs.14781
32. Kaur G, Sharma S, Nagi HP, Dar BN. 2012. Functional properties of pasta enriched with variable cereal brans. *J Food Sci Technol* 49(4): 467-474. https://doi.org/10.1007/s13197-011-0294-3
33. Bustos MC, Perez GT, Leon AE. 2011. Effect of four types of dietary fiber on the technological quality of pasta. *Food Sci Technol Int* 17(3): 213-221. https://doi.org/10.1177/1082013210382303