Full Length

STANDARDIZATION AND SENSORY EVALUATION OF ANTIOXIDANT ENRICHED PASTA WITH TANNER'S CASSIA (*SENNA AURICULATA*) AND SPINACH (*SPINACIA OLERACEA L.*)

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ABSTRACT

Spinach and Tanner's cassia, both are nutrient-dense leafy plants known for their high fibre and antioxidant content, making them valuable additions to a healthy diet and for overall wellbeing. This study was aimed to develop antioxidant rich pasta by incorporating spinach powder (Spinacia oleracea L.) and Tanner's Cassia (Senna auriculata) flower extract. Five distinct formulations were formulated, including a control (100% Maida) and four treatments (T1–T4) with varying levels of spinach powder (5%, 10%, 15% and 20%) and Tanner's Cassia flower extract (50 mL, 55 mL, 60 mL, 65 mL). Sensory evaluation was conducted using a 9-point hedonic scale to assess the appearance, texture, flavor, taste and overall acceptability. The results of this study showed that T2 (10% spinach powder) was the most preferred formulation, receiving the highest sensory scores across all attributes. The control and T2 (10% spinach powder) pasta samples showed notable differences in proximate composition and antioxidant activity. Antioxidant activity, assessed through the DPPH radical scavenging method and all treatment samples (T1, T2, T3 and T4) exhibited a significant increase (71%, 74%, 77.7% and 80%) compared to the control sample (2.0%). T2 and the control sample had higher levels of protein (12.23 ± 0.005% and 9.72 ± 0.002%), fat (3.98 ± 0.005% and 0.977 ± 0.004%), dietary fibre (6.86 ± 0.004% and 1.27 ± 0.004%) and ash content (4.42 ± 0.007% and 0.82 ± 0.004%), while carbohydrate content was lower (65.85 ± 0.02% and 80.07 ± 0.002%) during the comparative assessment. This study suggests that pasta enriched with 10% spinach powder and Tanner's Cassia flower extract (55 mL) can serve as a functional food, offering enhanced nutritional and health benefits with higher consumer acceptability, as supported by both sensory evaluation and antioxidant activity results.

Key words: *Antioxidant, Tanner's cassia, spinach, pasta.*

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INTRODUCTION

Extrusion is a process in which blended ingredients are pushed through a small opening, known as a die, to shape

and form materials (Shelar and Gaikwad, 2019). Semolina, a coarse flour from durum wheat, is valued for its gluten content and is widely used in pasta production. Though refined flour-based pasta is rich in carbohydrates, it lacks fibre and bioactive compounds may cause risk of diabetes, cancer and cardiovascular disease for health. Pasta quality depends on both sensory and cooking properties, including taste, texture, swelling, and cooking loss, while factors like raw materials, processing methods, dough mixing, and drying techniques are equally influential (Dziki, 2021).

Wheat flour, the primary ingredient in pasta, contains two key proteins: glutenin and gliadin. When mixed with water, these proteins combine to form gluten, which provides the dough with elasticity and structure. This gluten network allows the dough to stretch and retain its shape during shaping and cooking (Romano *et al*., 2021; Pahulpreet Kaur, 2023).

The dark green leafy vegetable spinach (*Spinacia oleracea* L.), which belongs to the Chenopodiaceae subfamily, is enjoyed by people all over the world because of its high nutritional content. Its antioxidant, antimicrobial and anticancer qualities are widely established (EI-Sayed, 2020).

As one of the most nutrient-dense vegetables, spinach contains a variety of phytonutrients and bioactive substances, including flavonoids, polyphenols, lutein, zeaxanthin, vitamin C (ascorbic acid) and β-carotene, all of which have important health advantages. Along with minerals including calcium, phosphorus, potassium, magnesium, iron, zinc, copper and manganese, it is also considered as a reasonably priced source of dietary fibre. According to Iacobellis *et al*. (2024), the leaves are especially high in phylloquinone or vitamin K1, which helps to alleviate bleeding issues.

Tanner's cassia, a leguminous shrub belonging to the Fabaceae family, is commonly known as Avaram in Tamil. This plant possesses notable therapeutic potential owing to its rich content of phytochemicals such as volatile oils, alkaloids, glycosides, tannins and saponins. Nearly every part of the plant from root to flower is valued for its medicinal properties, which include antioxidant, antimicrobial, antidiabetic, hepatoprotective, antiviral and antipyretic effects. Notably, the flower buds have been traditionally used in the treatment of diabetes (Girme *et al*., 2018). According to Meenupriya *et al.* (2014), the plant has been shown to have antipyretic, hepatoprotective, antidiabetic, antiperoxidative, antihyperglycemic and microbicidal qualities.

Conventional methods like refluxing and Soxhlet extraction often cause low yields due to compound degradation from oxidation, hydrolysis, long extraction times and high temperatures. To address this, green extraction techniques have emerged. Ultrasound-assisted extraction (UAE) is widely used for recovering bioactive compounds like nutraceuticals, antibiotics, polyphenols, flavanols and polysaccharides (Sharmila *et al*., 2016).

Rising urbanization, changing lifestyles and rising demand for ready to eat goods are the key drivers of the pasta market in India to rise. Pasta, especially made from refined flour, is high in simple carbohydrates and lacking essential nutrients, which may cause spikes in blood sugar levels and weight gain. Its limited fibre content may also contribute to digestive issues. Using spinach and tanner's cassia in pasta, improve antioxidant activity and other nutrients. This helps to improve digestion and combat oxidative stress.

Accordingly, this research focuses on the development of antioxidant enriched pasta by incorporating with spinach and extract of tanner's cassia flower and assessing the sensory evaluation of the developed product.

MATERIALS AND METHODS

The dry components utilized for the preparation of pasta include refined wheat flour or Maida, wheat flour, xanthan gum, salt and oil was procured from the local market in Redhills, Chennai, Tamil Nadu – 600 052.

Preparation of spinach and tanner's cassia flower powder

The Tanner's Cassia flower and fresh Spinach leaves were purchased from the local market in Redhills and they were gently washed with clean water to get rid of any contaminants. For a week, the flowers and leaves were kept under the shade of the sun for drying. To obtain a fine powder, the dried leaves and flower were grounded and sieved. The powdered sample was kept in an airtight container for further research work (El-Sayed, 2020).

Tanner's cassia flower extract- ultrasound extraction

Tanner's cassia (Senna auriculata) flower extract was prepared following a modified method described by Sharmila *et al*. (2016). Precisely 2 g of dried Tanner's Cassia flower powder was accurately weighed and transferred into a clean 250 ml beaker. To this, 100 mL of potable water was added and the mixture was stirred thoroughly to obtain a homogeneous suspension. The beaker was then placed in an ultrasonic water bath (LAB JUNCTION, India – LJ-321 model), and the temperature was maintained at 50°C throughout the extraction process. The ultrasonicator (20kHz) was operated continuously for a period of 30 minutes to enhance the release of bioactive compounds from the flower powder. Following sonication, the mixture was allowed to cool at room temperature and subsequently filtered through a clean muslin cloth to remove particulate matter. The resulting clear aqueous extract was collected and stored at 4°C until further analysis.

Development of antioxidant rich pasta

Antioxidant containing pasta in the shape of "Ziti" was preliminarily produced on the laboratory scale at the College of Food and Dairy Technology, Chennai - 600 052 using a mini pasta making machine (Dolly La Monferrina, Italy – 2017 model) with vat capacity of 2.5 Kg and extrusion screw speed of 80 rpm (Iacobellis *et al*., 2024).

The Ziti pasta was prepared according to Poorvitha, (2024) with the mixing of dry ingredients, including spinach powder (5%, 10%, 15% and 20%), Tanner's Cassia flower extract (50 mL, 55 mL, 60 mL, 65 mL), refined flour (Maida) and whole wheat flour (Table-1). Salt (2%), refined oil (8%) and xanthan gum (2%) are then added to improve taste, texture and binding. Moisture is adjusted through conditioning to achieve the appropriate dough consistency. The mixture is then kneaded thoroughly to ensure uniformity and smoothness. Cold extrusion is used to shape the dough, followed by steaming the product for 15 minutes. The steamed pieces are then dried using solar drying at a temperature of 60–70°C for 6 to 7 hours. Finally, the dried product is packed using HDPE packaging material, used for the sensory evaluation, analysis of nutrient content and antioxidant assay.

Sensory evaluation

Sensory evaluation of pasta was carried out using a 9-point hedonic scale by 15 semi- trained panelists (faculties and students) at College of Food and Dairy Technology, koduveli, Chennai – 600 052 to assess the flavor/taste, colour/appearance, texture and overall acceptability. Sensory evaluation was done at room temperature in between the hours of 03.00 to 04.00 pm. Normal water was served in between samples to eliminate the residual test of the previous sample.

Proximate content

Moisture content (oven dry method) was determined by AOAC (1990). The protein content of samples was determined by Kjeldahl procedure described in AOAC (2018). Fat content in the sample was estimated by Soxhlet extraction method (AOAC, 2000). The crude fibre of sample was estimated using a Fibrotron fibre analyzer as per AOAC (2000). AACC (2000) procedure was followed for ash determination. The total dietary fibre was measured as the sum of soluble and insoluble dietary fibre as described by Asp *et al*. (1983).

Antioxidant activity

About 6 mg of DPPH powder were carefully dissolved in 50 ml of ethanol to create an ethanolic DPPH (2,2-diphenyl-1-picrylhydrazyl) solution, making sure that the powder was completely dissolved to produce a homogenous solution. A clean test tube was filled with 100 µl of the sample extract, which had been properly tested to determine its antioxidant activity. 1ml of the newly made DPPH solution and 3 ml of ethanol were then added. To guarantee the correct interaction between the extract and the DPPH, the contents of the test tube were properly mixed. The antioxidant components in the extract were then allowed to react with the DPPH radicals for 120 minutes by incubating the reaction mixture at room temperature in the dark, as explained by Sharmila *et al.* (2016). After incubation, the absorbance of the resulting solution was measured at 520 nm using a UV-Visible spectrophotometer, with the blank. The scavenging ability was calculated using the following equation:

$$\text{Scavenging activity (\%)} = \frac{\text{A520 blank - A520 sample x 100}}{\text{A520 blank}}$$

RESULT AND DISCUSSIONS

Sensory evaluation

The sensory evaluation of developed antioxidant rich pasta is summarized in Table 2. The sensory evaluation was conducted using a 9-point hedonic scale to assess the flavor, taste, appearance and texture of pasta formulated with spinach powder and Tanner's cassia flower extract.

The study on incorporating spinach powder and Tanner's cassia flower extract in pasta formulation revealed that the T2 (10% spinach powder) was the most favorable in terms of flavor/taste (8.70±0.42), color/appearance (8.90±0.31) and texture (8.80±0.42) followed by control and T1 had flavor/taste (7.95±0.15 and 8.02±0.06), color/appearance (7.90±0.31 and 7.60±0.51), and texture (7.90±0.31 and 8.04±0.12) respectively.

Increasing the spinach powder concentration more than 10% (T3 and T4) resulted in stronger spinach flavour/ taste (6.70±0.42 and 5.90±0.31), darker colour (6.80±0.42 and 5.85±0.33) and a rougher texture (6.85±0.33 and 5.76±0.344) respectively, which reduced overall acceptability. Similarly, Iacobellis et al. (2024) reported that PSP12 (12% spinach powder) received higher overall acceptability in sensory analysis, whereas PSP25 (25% spinach powder) exhibited a more pronounced herbaceous flavor that may influence consumer preference.

Ramu *et al.* (2016) concluded that incorporating up to 20% spinach paste improved the sensory quality of instant noodles, while higher concentration levels negatively impacted texture, color, and overall acceptability. Thus, 20% spinach paste was found to be the optimal level for producing high-quality, consumer-acceptable instant noodles.

The T2 formulation (56g Maida, 30g wheat, 10g spinach powder, and 55ml Tanner's cassia flower extract) provided a balanced taste, appealing green color and smooth texture, making it the most preferred choice. The Tanner's cassia extract contributed mild herbal notes without overpowering the pasta's flavor. Therefore, incorporating 10% spinach powder in the pasta formulation offers an optimal combination of nutrition content and sensory appeal.

Proximate content

The proximate content of developed antioxidant rich pasta is summarized in Table 3. Compared to conventional refined flour pasta, pasta made with spinach powder and Tanner's cassia flower extract exhibited higher nutrient content. Control and treatment 2 pasta had protein (9.72±0.002 and 12.23±0.005), fat (0.977±0.004 and 3.98±0.005), dietary fibre (1.27 ±0.004 and 6.86±0.004) and ash (0.82±0.004 and 4.42±0.007) and lower carbohydrates (80.07±0.002 and 65.85±0.02) respectively. These improved values resulted from spinach's natural richness, bioavailability of dietary fibre, vitamins (A, C, K), minerals (calcium, magnesium, potassium), and antioxidants, which enhances both nutritional quality and health benefits.

Similarly, Ramu *et al*. (2016) reported that the incorporation of 20% spinach pastes into instant noodles resulted in an increase in moisture content (from 4.3 ± 0.15% to 6.6 ± 0.2%), protein (from 11.56 ± 0.30% to 12.53 ± 0.40%), fat (from 4.53 ± 0.15% to 11.59 ± 0.34%) and ash content (from 1.46 ± 0.15% to 2.53 ± 0.15%), whereas the carbohydrate content decreased (from 74.16 ± 2.95% to 65.33 ± 1.32%) respectively.

Followed by, Iacobellis et al. (2024) reported that spinach flour–enriched pasta showed notable differences in gross composition. Specifically, the PSP25 formulation had lower energy values and total carbohydrate content compared to the control pasta (CP). In contrast, PSP25 exhibited the highest fibre content (11.3 g), while PSP12 showed intermediate fibre levels (5.2 g).

Average of six trials; Non-significant – $P>0.05$; *Significant – $0.01<P\leq0.05$; **Highly significant - $P\leq0.01$

Antioxidant Assay

Tanner's cassia flower extract

The antioxidant activity of tanner's cassia flower extract was assessed by DPPH radical scavenging method. The study revealed that the ultrasonication extraction of tanner's cassia flower at 50ºC for 30 minutes enhanced the release of bioactive compounds like flavonoids and phenolic compounds from the flower powder and observed high score of (92.3%) scavenging activity, following the optimization by Sharmila *et al*. (2016) stated that the combination of 5 min extraction time, pH 6.2, 60% solvent concentration, and 50 W power yielded the highest antioxidant responses of TPC, FRAP and DPPH activities of 59.68 (mgGAE/g), 96.2 (mM Fe2+/g) and 90.5% respectively.

Developed antioxidant rich pasta

The antioxidant activity of developed pasta is showed in Figure 3. In this study, spinach and Tanner's cassia flower extracts were incorporated into pasta to evaluate their antioxidant potential using the DPPH radical scavenging method. The control pasta sample showed lower antioxidant activity of 2.0%, whereas pasta enriched with the extracts showed a significant increased antioxidant activity, with T1, T2, T3 and T4 showing 71.0%, 74.0%, 77.7% and 80.0% activity respectively. The increased antioxidant activity is attributed due to the presence of natural antioxidants such as flavonoids and phenolic compounds in spinach and Tanner's cassia. The results suggested that incorporating the spinach and Tanner's cassia flower extracts to pasta effectively enhances its antioxidant properties, as clearly shown in the below mentioned graph.

Similar to the findings of Iacobellis *et al.* (2024), spinach-enriched pasta exhibited greater antioxidant activity and retained higher levels of phenolic and flavonoid compounds after cooking compared to control pasta. According to Susanti *et al.* (2021), the incorporation of higher concentrations of spinach extract (SE) into wet noodles resulted in enhanced antioxidant activity.

CONCLUSION

This study successfully developed antioxidant-enriched pasta by incorporating spinach powder and Tanner's Cassia flower extract, both rich in fibre and antioxidants. Among the five formulations, T2 (10% spinach powder and 55 mL Tanner's Cassia extract) emerged as an optimal formulation; showing significantly increased nutritional composition compared to the control pasta sample. T2 contained higher protein, fat, dietary fibre and ash content, with lower carbohydrates. Antioxidant activity, assessed via the DPPH method, was also showed significantly higher results in T2 compared to the control sample. Sensory evaluation confirmed T2 sample as the most preferred formulation across all attributes. These findings suggests that pasta enriched with 10% spinach powder and 55 mL Tanner's Cassia extract can serve as a functional food with enhanced nutritional value, antioxidant potential and higher consumer acceptability. From a market perspective, such functional pasta products align well with growing consumer demands for health-oriented and antioxidant-rich foods. The incorporation of familiar and naturally derived ingredients like spinach and Tanner's Cassia not only supports clean-label product development but also offers differentiation in the competitive pasta market. With appropriate positioning, this formulation has strong commercial potential in the health and wellness food segment, particularly among individuals seeking digestive health benefits and enhanced nutritional profiles without compromising taste or dietary quality. Future studies will be conducted to investigate the effects of various storage conditions on the physicochemical properties and shelf life of pasta.

Fig.1. Developed Antioxidant Rich Pasta

Table.1. Standardization of Antioxidant Rich Pasta

Ingredients (100g)/ Treatment	Maida (g)	Wheat Flour (g)	Spinach powder\ (g)	Refined oil (ml)	Salt (g)	Xanthan gum (g)	Water (ml)	Flower extract (ml)
Control	96	-	-	8	2	2	40	-
T_1	61	30	5	8	2	2	-	50
T_2	56	30	10	8	2	2	-	55
T_3	51	30	15	8	2	2	-	60
T4	46	30	20	8	2	2	-	65

Table.2. Standardization of Antioxidant Rich Pasta

Treatment	Appearance/color	Flavor/ taste	Texture	Overall acceptability
Control	7.90±0.31^{c}	7.95±0.15^{c}	7.90±0.31^{c}	7.93±0.11^{c}
T1	7.60±0.51^{c}	8.02±0.06^{c}	8.04±0.12^{c}	7.88±0.19^{c}
T2	8.90±0.31^{d}	8.70±0.42^{d}	8.80±0.42^{d}	8.80±0.21^{d}
T3	6.80±0.42^{b}	6.70±0.42^{b}	6.85±0.33^{b}	6.78±0.26^{b}
T4	5.85±0.33^{a}	5.90±0.31^{a}	5.55±0.59^{a}	5.76±0.344^{a}
F value	8.396*	131.624**	103.471**	240.900*

Average of Six trials; Non-significant – P>0.05; *Significant – 0.01<P≤0.05; **Highly significant - P≤0.01

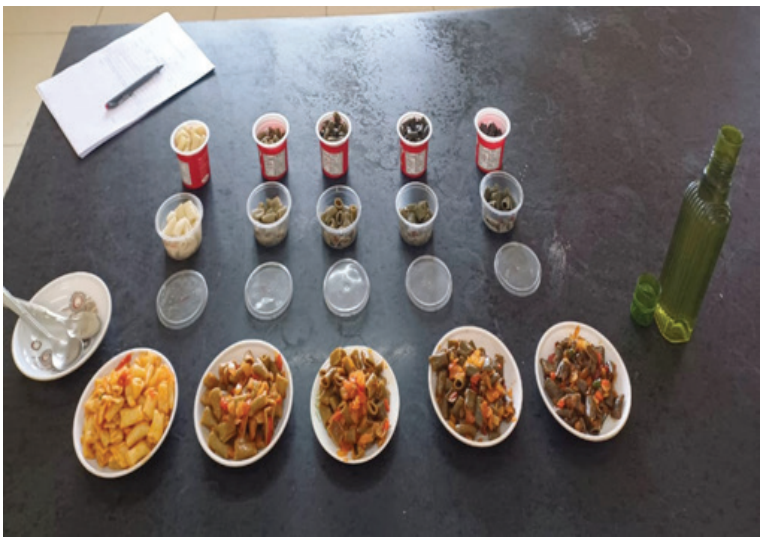

Fig.2. Sensory Evaluation of Antioxidant Rich Pasta

Table.3. Proximate content of developed Antioxidant Rich Pasta

Proximate content/ Treatment	Control	Treatment 2	t value
Moisture (%)	7.11±0.004	6.62±0.005	166.235*
Protein (%)	9.72±0.002	12.23±0.005	25.428**
Fat (%)	0.977±0.004	3.98±0.005	1047.488*
Dietary fibre (%)	1.27 ±0.004	6.86±0.004	2225.679*
Carbohydrate (%)	80.07±0.002	65.85±0.02	143.010**
Ash (%)	0.82±0.004	4.42±0.007	987.958*

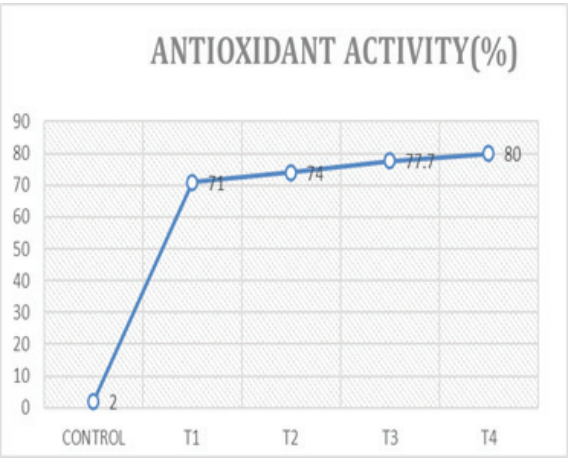

Fig.3. Antioxidant Activity of Developed Pasta

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