Formulation and Quality Assessment of a Ready-to-Cook Premix Using Underutilized Tanner's Cassia (*Senna auriculata*) Flower

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DOI: https://doi.org/10.47772/IJRISS.2026.100601363

Received: 06 July 2026; Accepted: 11 July 2026; Published: 20 July 2026

ABSTRACT

Senna auriculata (Tanner's cassia), a traditionally used medicinal shrub native to India and Sri Lanka, possesses well-documented antioxidant, antidiabetic, antimicrobial, and anti-inflammatory properties attributed to bioactive compounds such as flavonoids, phenolics, tannins, and glycosides. Despite its therapeutic potential, this flower remains largely underutilized in food product development. The present study aimed to formulate and evaluate a nutritionally enhanced ready-to-cook (RTC) dosa premix incorporating Tanner's cassia flower powder. Three variations (V1, V2, V3), containing 10%, 15%, and 20% cassia flower powder respectively, were developed using a base of semolina, sorghum millet, foxtail millet, and urad dal, and compared against a standard control premix (C-0) without cassia. Organoleptic evaluation using a 9-point hedonic scale identified Variation 2 (15% cassia flower) as the most acceptable formulation, recording the highest scores for colour, appearance, and overall acceptability (8.4). Physicochemical analysis showed comparable water absorption capacity, oil absorption capacity, and pH stability between V2 and the control. Proximate analysis of V2 revealed an energy value of 363.99 kcal/100 g, carbohydrate 73.64 g/100 g, protein 12.71 g/100 g, fat 2.07 g/100 g, and crude fibre 12.7 g/100 g. Micronutrient analysis demonstrated notable iron (17.41 mg/100 g) and zinc (1.21 mg/100 g) content, with oxalate levels (43.82 mg/100 g) within safe dietary limits. Compared with two commercially available dosa premixes, the developed formulation exhibited the lowest fat content while maintaining comparable protein and carbohydrate values. The DPPH radical scavenging assay confirmed moderate antioxidant activity (IC50 = 78.19 µg/mL). These findings demonstrate that Tanner's cassia flower can be successfully incorporated into a millet-based RTC premix to enhance nutritional and functional value without compromising sensory acceptability, supporting the sustainable utilization of this underexploited medicinal plant in functional food development.

Keywords: *Senna auriculata;* Tanner's cassia; ready-to-cook premix; millet-based food; functional food

INTRODUCTION

Senna auriculata, commonly known as Tanner's cassia, Avaram, or Avaramsenna, is a flowering leguminous shrub of the Fabaceae family that grows widely across the tropical and subtropical regions of India and Sri Lanka. The plant thrives in diverse and often degraded ecosystems, including roadside patches, rocky terrain, and riverbanks, and has long been valued by indigenous communities for both ecological resilience and medicinal use. Its documented presence in Ayurvedic and Siddha texts reflects a sustained traditional application in managing diabetes, skin ailments, eye infections, and urinary disorders (Nille et al., 2021).

Various plant parts such as flowers, leaves, seeds, bark, and pods exhibit a broad spectrum of pharmacological activity, including antidiabetic, antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, nephroprotective, and antihyperlipidemic effects (Murugan et al., 2013; Jancy et al., 2021). These properties are largely attributed to bioactive constituents such as flavonoids (notably quercetin), tannins, alkaloids, glycosides, steroids, saponins, and phenolic acids (Soundharajan & Ponnusamy, 2014). Of particular interest is the plant's hypoglycaemic potential: extracts of *Senna auriculata* have been shown to lower fasting and postprandial blood glucose in diabetic animal models, an effect linked to enhanced peripheral glucose uptake, inhibition of carbohydrate-digesting enzymes, and modulation of insulin release (Vijayaraj et al., 2013; Salma et al., 2020).

Beyond its pharmacological relevance, *Senna auriculata* also carries nutritional value. Its flowers, traditionally consumed as teas, powders, and chutneys in South Indian communities, are notably rich in iron, calcium, zinc, and dietary fibre (Sahoo et al., 2024). This dual therapeutic and nutritional profile positions the flower as a strong candidate for incorporation into functional food systems, particularly ready-to-cook (RTC) formulations that can deliver these benefits conveniently to time-constrained, health-conscious consumers. Despite this potential, Tanner's cassia remains an underutilized botanical resource in commercial food product development.

This study, therefore, sought to develop an RTC dosa premix enriched with Tanner's cassia flower powder as a means of promoting the sustainable utilization of this underexploited plant while enhancing the nutritional profile of a traditional South Indian staple. The specific objectives were: (i) to formulate a nutritionally enhanced RTC premix incorporating varying proportions of Tanner's cassia flower; (ii) to evaluate the organoleptic properties of the developed variations and identify the most acceptable formulation; and (iii) to assess the nutritional composition and antioxidant potential of the best-performing variation.

LITERATURE REVIEW

Botanical Description and Phytochemistry

Taxonomically reclassified from the broad genus Cassia into the genus Senna, *Senna auriculata* (L.) Roxb. belongs to the family Fabaceae, subfamily Caesalpinioideae, and tribe Cassieae (Kumar et al., 2021; Nille et al., 2021). The shrub is characterised by oblong-obovate leaflets, bright yellow flowers up to 5 cm in diameter, and flat, papery pods containing 10–20 seeds (Kumar et al., 2021).

Phytochemical screening consistently reports a dominant presence of flavonoids and phenolic compounds, with moderate levels of tannins, terpenoids, alkaloids, and steroids, and lower quantities of saponins, glycosides, and coumarins (Pandiyan & Ambiga, 2021). Specific flavonoids such as quercetin, epicatechin, and proanthocyanidin B1 have been isolated from the flower and are associated with antidiabetic and antitumour activity (Nille et al., 2021).

Pharmacological Properties

Multiple pharmacological effects have been documented for *Senna auriculata* flower extracts. Ethanolic and ethyl acetate extracts exhibit strong DPPH and ABTS radical scavenging activity comparable to synthetic antioxidants such as BHT (Jancy et al., 2021; Hitesh Gowda et al., 2022). Anti-inflammatory activity, assessed via egg albumin denaturation and carrageenan-induced rat paw oedema assays, has been attributed to flavonoids such as 5-O-methylquercetin 7-O-glucoside (Ganesh et al., 2021; Anitha et al., 2020).

Antimicrobial studies report inhibitory activity against Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, and Candida albicans (Rahman et al., 2024), while hepatoprotective and nephroprotective effects have been demonstrated in ethanol- and drug-induced toxicity models (Aarathi & Sendhilvadivu, 2024; Annie et al., 2005). Antidiabetic and anti-hyperlipidaemic activities, including reductions in blood glucose, total cholesterol, LDL, and triglycerides, have also been reported in streptozotocin-induced diabetic and hyperlipidaemic rat models (Pari & Latha, 2002; Vijayaraj et al., 2013).

Millets as Functional Food Ingredients

Millets, often termed "nutri-cereals," are gluten-free, nutrient-dense grains rich in protein, dietary fibre, minerals (iron, magnesium, phosphorus), and antioxidants, with a comparatively low glycaemic index (Kalsi & Bhasin, 2023). Their inclusion in cereal-based formulations has been shown to improve fibre content, slow glucose release, and support cardiometabolic health (Stefoska-Needham, 2024), making them a suitable base for a health-oriented RTC premix.

Ready-to-Cook Foods and Packaging

The growing demand for convenience foods, driven by urbanisation, time constraints, and increased workforce participation among women, has fuelled the popularity of RTC products such as premixes, marinated proteins, and partially processed vegetables (Mathew & Sharma, 2023; Peltner & Thiele, 2018). Packaging materials for such dry mixes must provide adequate barrier protection against moisture, oxygen, and light; laminated aluminium foil pouches are widely used for this purpose owing to their non-reactivity and resistance to gas and vapour transmission (Julyanti et al., 2024; Deshwal et al., 2019).

MATERIALS AND METHODS

Study Design

The study was conducted in two phases. Phase 1 comprised standardization of the dosa premix and development of three cassia-enriched variations (V1, V2, V3), followed by sensory evaluation to identify the most acceptable formulation. Phase 2 comprised physicochemical, proximate, micronutrient, antioxidant, and anti-nutrient (oxalate) analysis of the selected formulation, along with statistical analysis and packaging design.

Raw Material Procurement and Processing

Cereal and pulse ingredients (semolina, sorghum millet, foxtail millet, urad dal, Bengal gram dal) were procured from the local market in Bengaluru; Tanner's cassia flowers were hand-collected from Varthur, Bengaluru. Millets and dal were soaked overnight, sun-dried for 4–5 hours, dry-roasted, and milled into fine powder. Cassia flowers were cleaned, blanched for 2–3 minutes, shade-dried for four days, and separately milled and sieved.

Formulation

A constant base of semolina and urad dal was used across all formulations, with sorghum millet, foxtail millet, peanut, Bengal gram dal, and Tanner's cassia flower powder varied as shown in Table 1. The control (C-0) contained no cassia flower, while V1, V2, and V3 contained 10%, 15%, and 20% cassia flower powder, respectively.

Table 1. Formulation of the developed dosa premix (g per 100 g)

Ingredient (g/100 g)	**C-0**	**V-1**	**V-2**	**V-3**
Semolina	30%	30%	30%	30%
Sorghum millet	25%	20%	20%	20%
Foxtail millet	20%	20%	15%	15%
Urad dal	15%	15%	15%	15%
Peanut	5%	-	-	-
Bengal gram dal	5%	5%	5%	-
Tanner's cassia flower	-	10%	15%	20%
Total	**100%**	**100%**	**100%**	**100%**

[C= standard/ control, V1= variation 1, V2= variation 2, V3= variation 3]

Sensory Evaluation

Cooked dosa samples prepared from each formulation were evaluated by a semi-trained panel of members [panel size (n) = 30] using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely) for colour, appearance, texture, taste, flavour, aroma, and overall acceptability. Panelists were selected on the basis of prior sensory panel experience, absence of reported taste/smell impairment, and non-smoking status and were briefed on the scoring protocol prior to evaluation; panel size was not derived from a formal power calculation, which is noted as a limitation below. Samples were served in randomised, three-digit coded order under standard lighting with water provided for palate cleansing between samples.

Physicochemical Analysis

Water absorption capacity (WAC) and oil absorption capacity (OAC) were determined by the centrifugation methods of Sosulski (1962) and Lin et al. (1974), respectively. Batter pH was measured before and after 30 minutes of fermentation using a calibrated digital pH meter. Diameter, thickness, spread ratio, cooking time, and cooked weight of the dosa were recorded in triplicate (Gupta et al., 2011).

Proximate, Micronutrient, and Anti-nutrient Analysis

Moisture, ash, protein (Kjeldahl method), fat (Soxhlet extraction), crude fibre, and carbohydrate (by difference) were determined following FSSAI (2023) and FAO (2003) protocols. Iron and zinc were quantified using inductively coupled plasma optical emission spectroscopy (ICP-OES) following sequential extraction (Oral, 2016). Oxalate content was estimated by titration (Karamad et al., 2019).

Antioxidant Analysis

Antioxidant activity was assessed using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay across a concentration range of 0–640 µg/mL, with ascorbic acid as reference. Percentage radical scavenging activity (%RSA) and IC50 were calculated (Brand-Williams et al., 1995).

Statistical Analysis

Data were expressed as mean ± standard deviation of triplicate determinations and analysed using one-way Analysis of Variance (ANOVA) with post-hoc comparisons ($p < 0.05$) in Microsoft Excel and SPSS v25.0 (Montgomery, 2017).

RESULTS AND DISCUSSION

Organoleptic Evaluation

Sensory scores for the four formulations are summarised in Table 2. Variation 2 (15% cassia flower) recorded the highest scores for colour (8.4), appearance (8.3), texture (8.3), and overall acceptability (8.4), while Variation 1 (10% cassia flower) scored highest for taste and flavour (8.4). Variation 3 (20% cassia flower) was rated lowest across all attributes (overall acceptability 7.3), suggesting that higher proportions of cassia flower powder adversely affected taste and texture, likely due to increased fibre and phenolic content imparting a more pronounced bitterness. These results indicate that a moderate inclusion level (15%) provides an optimal balance between the functional contribution of Tanner's cassia and consumer acceptability, consistent with the flavonoid- and mineral-rich profile of millets and cassia flowers enhancing texture, aroma, and nutritional density without compromising palatability (Arora et al., 2023; Khyade et al., 2020).

Table 2. Mean sensory scores of the dosa premix formulations (9-point hedonic scale)

Attribute	C-0	V-1	V-2	V-3	P- value	F- value
Appearance	8.3 ± 0.33^{a}	8.2 ± 0.33^{b}	8.3 ± 0.33^{a}	7.6 ± 0.33^{c}	0.99	0.059
Colour	8.3 ± 0.35^{b}	8.2 ± 0.35^{c}	8.4 ± 0.35^{a}	7.6 ± 0.35^{d}		
Texture	8.1 ± 0.42^{c}	8.2 ± 0.42^{b}	8.3 ± 0.42^{a}	7.4 ± 0.42^{d}		
Taste	8.1 ± 0.46^{c}	8.4 ± 0.46^{a}	8.2 ± 0.46^{b}	7.4 ± 0.46^{d}		
Flavour	8.2 ± 0.43^{b}	8.4 ± 0.43^{a}	8.2 ± 0.43^{b}	7.4 ± 0.43^{c}		

Aroma	8 ± 0.36^{b}	8.2 ± 0.36^{a}	8.2 ± 0.36^{a}	7.5 ± 0.36^{c}		
Overall acceptability	8.2 ± 0.49^{c}	8.3 ± 0.49^{b}	8.4 ± 0.49^{a}	7.3 ± 0.49^{d}		

Data expressed as Mean ± Standard deviation of triplicates. Values with the same superscripts (a, b, c) in the same row are not significantly different ($p < 0.05$)

Based on the overall acceptability scores, Variation 2 (V2) was selected as the optimal formulation and was subjected to further physicochemical and nutritional analysis in comparison with the control (C-0).

Physicochemical Properties

The water absorption capacity of V2 (0.20 ± 0.04 g/g) was marginally higher than that of the control (0.17 ± 0.04 g/g), indicating improved moisture retention, while oil absorption capacity remained identical (0.20 ± 0.00 g/g) for both samples. Batter pH increased mildly after fermentation in both samples (control: 5.71 to 5.81; V2: 5.81 to 5.97), consistent with partial fermentation activity (Sanni et al., 2001). Cooked V2 dosa exhibited a marginally smaller diameter (16.7 cm vs. 16.9 cm) and lower spread ratio (79.5 vs. 84.5) than the control, likely reflecting the higher water-binding capacity of the cassia-enriched batter; cooking time was correspondingly longer (4.06 vs. 3.36 minutes), though this difference was not statistically significant ($p = 0.06$).

Table 3: Physicochemical evaluation of the Tanner's cassia Dosa Premix

Sample	WAC	OAC	pH-A	pH-B	P- value	F- value
C	0.17 ± 0.04^{b}	0.2 ± 0^{a}	5.71 ± 0.07^{b}	5.81 ± 0.11^{b}	0.12	2.59
V2	0.2 ± 0.04^{a}	0.2 ± 0^{a}	5.81 ± 0.07^{a}	5.97 ± 0.11^{a}		

Table 4: Physicochemical evaluation of the cooked Tanner's cassia Dosa Premix

Variation	Diameter	Thickness	Spread ratio	Cooking time	Weight of the cooked product	P- value	F- value
C	16.9 ± 0.1^{d}	0.2 ± 0^{e}	84.5 ± 3.5^{b}	3.36 ± 0.49^{c}	36 ± 4.2^{a}	0.05	3.16
V2	16.7 ± 0.1^{d}	0.21 ± 0^{e}	79.5 ± 3.5^{b}	4.06 ± 0.49^{c}	30 ± 4.2^{a}		

Proximate Composition

The nutrient profile of the selected V2 premix is summarised in Table 3. The formulation delivered 363.99 kcal, 73.64 g carbohydrate, 12.71 g protein, 2.07 g fat, and 12.7 g crude fibre per 100 g, alongside enhanced iron (17.41 mg/100 g) and zinc (1.21 mg/100 g) content attributable to the cassia flower inclusion.

Table 5. Proximate, micronutrient, and oxalate profile of the developed premix (V2)

Parameter	Result	Method
Ash	3.64 g/kg	FSSAI manual
Moisture	6.67 g/kg	FSSAI manual
Energy	363.99 kcal	FSSAI manual
Carbohydrate	73.64 g/100 g	FSSAI manual
Protein	12.71 g/100 g	FSSAI manual (Kjeldahl)
Fat	2.07 g/100 g	FSSAI manual (Soxhlet)

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VI June 2026

Crude fibre	12.7 g/100 g	FSSAI manual
Zinc	1.21 mg/100 g	ICP-OES
Iron	17.41 mg/100 g	ICP-OES
Oxalate	43.82 mg/100 g	Titration

The oxalate content of 43.82 mg/100 g was well below the reported oral LD50 range of oxalic acid in rats (375–475 mg/kg body weight) and the lowest published lethal dose in humans (~600 mg/kg) (Gosselin et al., 1984; Smyth et al., 1962), confirming its safety within a normal dietary intake, particularly when paired with adequate calcium intake (Massey et al., 2001).

Comparison with Commercial Dosa Premixes

The developed premix was benchmarked against two commercially available products: a rice-based dosa mix (CDP-1) and a millet-based dosa mix (CDP-2). As shown in Table 4, the developed premix contained the lowest fat content (2.07 g) among the three products, while carbohydrate (73.64 g) and protein (12.71 g) values were comparable to the millet-based commercial mix. The lower fat content supports its suitability for cardiovascular health-conscious consumers (Astrup et al., 2011), while the reduced caloric value (363.99 kcal vs. 375 and 386.8 kcal for CDP-1 and CDP-2, respectively) reflects the inclusion of cassia flowers, which contribute functional bioactive compounds without substantially increasing energy density (Sahoo et al., 2024).

Table 6. Macronutrient and energy comparison with commercially available dosa premixes

Parameter	**CDP-1 (Rice-based)**	**CDP-2 (Millet-based)**	**Developed Premix (V2)**
Protein (g/100 g)	12	13	12.71
Carbohydrate (g/100 g)	65.6	75.4	73.64
Total fat (g/100 g)	6	3.8	2.07
Energy (kcal/100 g)	375	386.8	363.99

Antioxidant Activity

The DPPH assay demonstrated a concentration-dependent increase in radical scavenging activity, from 39.60% at 10 µg/mL to 97.36% at 640 µg/mL, yielding an IC50 of 78.19 µg/mL. This indicates moderate but appreciable antioxidant capacity, consistent with the flavonoid and phenolic content contributed by the cassia flower, and supports the formulation's potential role in mitigating oxidative-stress-related conditions such as cardiovascular disease and certain cancers (Brand-Williams et al., 1995). To contextualise this value, the IC50 of the developed premix (78.19 µg/mL) is substantially higher (i.e., weaker) than that of ascorbic acid itself under the same assay conditions (Table 7), confirming that the premix is markedly less potent than a pure reference antioxidant, as would be expected for a food matrix diluted with cereal and legume components.

It is, however, closely comparable to the DPPH IC50 reported for a methanolic *Senna auriculata* leaf extract (76.24 µg/mL; Prasathkumar et al., 2021), indicating that the antioxidant contribution of the cassia flower survives incorporation into the millet-based matrix relatively well, and is considerably more potent than IC50 values reported for some other functional cereal-legume premixes and millet-based products in the literature.

Nonetheless, the DPPH assay measures only in vitro chemical radical-scavenging capacity in a non-physiological system, it does not establish bioavailability, absorption, or an actual antioxidant effect within the human body, and the biological or health significance of this IC50 value therefore remains inferential until confirmed by cell-based, animal, or human studies.

Table 7. Comparative % DPPH inhibition values of Ascorbic acid and Tanner's cassia Premix with IC50 concentration

Conc (µg/ml)	Control	Tanner's cassia Premix	% RSA	IC_{50} (µg/ml)
0	0.606	0.000	0.00	**78.19**
10	0.606	0.366	39.60	**78.19**
20	0.606	0.302	50.17	**78.19**
40	0.606	0.286	52.81	**78.19**
80	0.606	0.217	64.19	**78.19**
160	0.606	0.125	79.37	**78.19**
320	0.606	0.093	84.65	**78.19**
640	0.606	0.016	97.36	**78.19**

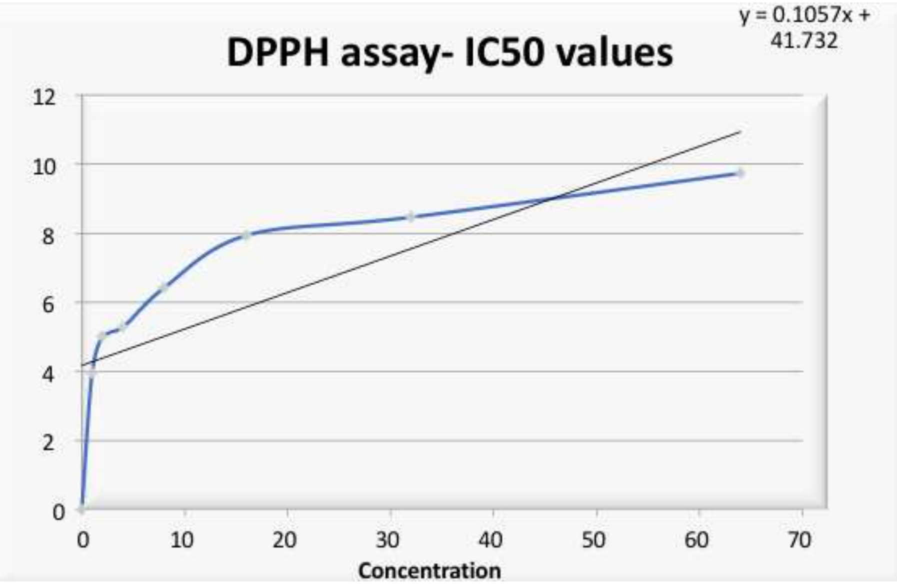

Fig 1: DPPH assay of Ascorbic acid and Tanner's cassia Premix at IC50 concentration

CONCLUSION

This study demonstrates that Tanner's cassia (*Senna auriculata*) flower, an underutilized medicinal plant, can be successfully incorporated into a millet-based ready-to-cook dosa premix to enhance its nutritional and functional profile without compromising consumer acceptability. Among the formulations developed, Variation 2 (15% cassia flower) emerged as the most nutritionally balanced and sensory-preferred option, offering high fibre and iron content, moderate protein, the lowest fat content relative to commercial alternatives, and moderate antioxidant activity (IC50 = 78.19 µg/mL). These findings support the feasibility of integrating traditional medicinal botanicals into convenient, health-oriented food products, contributing to both dietary diversification and the sustainable utilization of underexploited plant resources.

The study has several limitations. First, the sensory panel size, demographic composition, and selection criteria were not derived from a formal sample-size calculation, which constrains the statistical power and reproducibility of the organoleptic findings; future studies should report these parameters in full and, where feasible, pre-register a target panel size based on expected effect size. Second, this study was confined to laboratory-scale sensory and analytical evaluation and did not include a shelf-life or storage-stability assessment (e.g., changes in moisture, oxidative rancidity, or sensory quality over defined storage intervals and packaging conditions), a microbiological safety evaluation (e.g., total viable count, yeast/mould count, and pathogen screening per FSSAI or equivalent food-safety standards), or consumer acceptability testing in a larger, more demographically diverse population beyond the semi-trained panel used here; these are essential next steps before the premix could be considered ready for commercial-scale deployment. Third, while the DPPH-based antioxidant activity is broadly comparable to that reported for other *Senna auriculata* plant parts (Prasathkumar et al., 2021), this in vitro chemical assay does not establish the biological or physiological significance of the IC50 value, and no clinical or bioavailability studies were conducted to substantiate any implied health benefit. Future research should therefore prioritize: (i) shelf-life and packaging performance studies under real storage conditions; (ii) microbiological quality and safety evaluation; (iii) consumer acceptability testing across larger and more demographically varied populations; (iv) human intervention studies to evaluate glycaemic response, antioxidant status, and iron-absorption/bioavailability outcomes; (v) more comprehensive micronutrient and anti-nutrient profiling, in order to support the development of scientifically robust, validated functional food products based on Tanner's cassia.

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