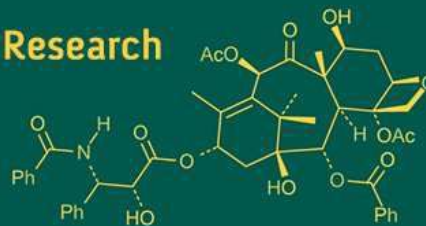


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Venugopala L
M. Sc. Scholar, Department of
Postharvest Management,
College of Horticulture,
Bengaluru, University of
Horticultural Sciences, Bagalkot,
Karnataka, India

Dr. Sadanand GK
Assistant Professor, Department
of Postharvest Management,
University of Horticultural
Sciences, Bagalkot, Karnataka,
India

Dr. Preethi P
Scientist, Division of PHT &
Agri. Engg., IIHR, Bengaluru,
Karnataka, India

Dr. Vasudeva KR
Professor and Uni. Head,
Department of Postharvest
Management, University of
Horticultural Sciences, Bagalkot,
Karnataka, India

Dr. Shivanand Veerappa Hongal
Senior Scientist and Head, KVK,
Kolar, Karnataka, India

Dr. Suresha GJ
Associate Professor, Department
of Postharvest Management,
University of Horticultural
Sciences, Bagalkot, Karnataka,
India

Kiran Kumar N
Assistant Professor of PHT
ZAHRS, Brahmavar,
KSNUAHS, Iruvakkki,
Karnataka, India

Manasa E
Ph.D. Scholar, Department of
Postharvest Management,
College of Horticulture,
Bengaluru, University of
Horticultural Sciences, Bagalkot,
Karnataka, India

Corresponding Author:
Venugopala L
M. Sc. Scholar, Department of
Postharvest Management,
College of Horticulture,
Bengaluru, University of
Horticultural Sciences, Bagalkot,
Karnataka, India

Effect of tannia flour and moisture content on the quality of extruded ready-to-eat snack

Venugopala L, Sadanand GK, Preethi P, Vasudeva KR, Shivanand Veerappa Hongal, Suresha GJ, Kiran Kumar N and Manasa E

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Abstract

Tannia (*Xanthosoma sagittifolium*), an underutilized tuber crop, possesses considerable nutritional potential and offers scope for its utilization in value-added food products. The present investigation was carried out at the Department of Postharvest Management, College of Horticulture, Bengaluru, during 2024–2025, with the objective of studying the effect of tannia flour concentration and feed moisture on the quality characteristics of an extruded ready-to-eat (RTE) snack. The experiment was conducted with tannia flour levels (50–80%) and feed moisture content (14–18%) were selected as independent variables. The extruded products were evaluated for quality parameters. Model fitting indicated that an optimized formulation consisting of 74.67 per cent tannia flour with 17.17 per cent feed moisture yielded desirable quality attributes, including protein (2.55%), fat (2.20%), starch (72.63%), crude fibre (3.05%), ash (2.43%), moisture content (3.35%), bulk density (0.14 g cm⁻³). Across treatments, increasing tannia concentration and feed moisture resulted in a significant increase in starch, fat, crude fibre, ash, moisture content and bulk density. Conversely, protein content exhibited a decreasing trend. Sensory evaluation using a 9-point hedonic scale revealed that moderate levels of tannia flour and feed moisture produced extrudates with superior overall acceptability.

Keywords: Tannia (*Xanthosoma sagittifolium*), extrusion technology, ready-to-eat (RTE) snacks

1. Introduction

The increasing demand for convenient ready-to-eat (RTE) snacks, coupled with growing public-health concerns over nutritionally imbalanced commercial snack foods, has intensified interest in developing healthier, nutrient-dense alternatives (Navale *et al.*, 2015; Grasso, 2020) [9, 5]. Extrusion cooking, a high-temperature short-time process, offers a versatile platform for producing shelf-stable, texturally acceptable snacks while enabling incorporation of under-utilised, nutrient-rich raw materials (Chauhan *et al.*, 2022; Scott *et al.*, 2000) [3, 15]. Tannia (*Xanthosoma sagittifolium*), an under-exploited tropical tuber rich in starch, dietary fibre and essential minerals, exhibits functional properties suitable for extrusion processing (Shah *et al.*, 2019) [16]. However, the quality attributes of extruded products are strongly influenced by formulation variables, particularly flour composition and feed moisture content, which govern expansion, texture, density and sensory acceptability. In this context, the present study aims to evaluate the effect of varying levels of tannia flour and moisture content on the physical, nutritional and sensory quality of extruded RTE snacks, with the objective of optimizing processing conditions for development of a nutritionally enhanced, consumer-acceptable and sustainable snack product.

2. Materials and Methods

The raw materials utilized in the development of the extruded product included maize grits, tannia flour. Maize grits were sourced from Prestige Enterprises, APMC Yard, Yeshwantpur, Begaluru. Tannia tubers were procured from the farmer name raju's field in ajjur village of Arkalgud, Hassan.

Tannia tubers were peeled, washed, sliced uniformly, and tray-dried at 60 °C for 6–8 h with intermittent turning until moisture content fell below 10%. The dried slices were ground into flour, packed in sealed bags, and stored for further use. For extrusion Twin screw Extruder was used. The extruded product was placed in a dehydrator set to 60 °C for approximately 45

minutes to achieve the desired crispness and moisture level. Finally, the samples were packed in aluminium laminated polyethylene (ALPE) pouches for further study.

Design model: Response surface methodology

Design: Central Composite Design

Runs: 10

Table 1: Factors and range of ingredients used in the experiment

Factor	Name	Unit	Min	Max	Coded low	Coded high
A	Tannia	%	50.00	80.00	-1 ↔ 50.00	+1 ↔ 80.00
B	Moisture	%	14.00	18.00	-1 ↔ 14.00	+1 ↔ 18.00

2.1 Total protein (%)

To determine the total protein content, the Lowry method (Lowry *et al.*, 1951) [7] was employed

$$\text{Total protein (\%)} = \frac{\text{OD } 660 \times \text{Std.value (mg)} \times \text{Total vol.of extract}}{\text{Assay Volume} \times \text{wt.of the sample (g)} \times 1000} \times 100$$

2.2 Fat (%)

The percentage of fat was calculated using the formula specified by AOAC (2006) [1].

$$\text{Fat (\%)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Weight of sample}} \times 100$$

2.3 Starch (%)

A 5 g sample was extracted, hydrolyzed with concentrated HCl, neutralized, and the volume adjusted to obtain reducing sugars following Osborne and Voogt (1978) [11].

Reducing sugars were estimated by the Lane and Eynon (1923) [6] titration method using Fehling's solution and methylene blue indicator, and results were expressed as percentage on sample weight basis.

$$\text{Reducing sugars (\%)} = \frac{\text{Factor (0.05)} \times \text{Volume made up} \times \text{Dilution} \times 100}{\text{Titre value} \times \text{Weight of the sample}}$$

$$\text{Starch (\%)} = (\%) \text{ Reducing sugar} \times 0.90$$

2.4 Total Carbohydrate (%)

Total carbohydrate content was measured using the phenol-sulfuric acid assay. the method outlined by Masuko *et al.* (2005) [8].

Calculation

Absorbance corresponds to 0.1 ml of the sample = 'x' mg of glucose.

$$\text{Total carbohydrate (\%)} = \frac{x}{0.10} \times 100$$

2.5 Crude Fibre (%)

The crude fibre content of the sample was determined using the double digestion method described by Sadasivam and Manickam (2005) [14]. The residue was transferred to a pre-weighed ash dish (W_1), dried for 2 hours in a desiccator, and weighed (W_2). The dried residue was then ignited in a muffle furnace at 600 °C for 30 minutes, cooled, and reweighed (W_3).

$$\text{Crude fibre (\%)} = \frac{\text{Loss in weigh on ignition}}{\text{Weight of the sample}} \times 100$$

Where, Loss in weight on ignition = ($W_2 - W_1$) – ($W_3 - W_1$)

2.6 Ash content (%)

Ash content was determined using a muffle furnace (AOAC, 2006) [1]. The ash content was calculated using the following formula.

$$\text{Total ash (\%)} = \frac{C-A}{B-A} \times 100$$

Where, A - Weight of empty crucible; B - Weight of sample + crucible; C - Weight of sample after ashing

2.7 Moisture content (%)

The moisture content of a known sample quantity was determined using an infrared moisture analyser (Sartorius MA 35) and expressed as a percentage (Tejas *et al.*, 2021) [18].

2.8 Bulk Density (g cm⁻³)

To measure bulk density, the volume of a perfectly rectangular wooden box was computed by multiplying its length, width, and height ($l \times b \times h$). The box was then filled with the extruded product up to the top level. The amount of product required to fill the box was recorded. Bulk density was calculated using the formula,

$$\text{Bulk density (g/cm}^3\text{)} = \frac{\text{Mass of extrudate (g)}}{\text{Volume of extrudate (cm}^3\text{)}}$$

3. Results and Discussion

In the present study, the tannia-based extruded snacks exhibited notable differences in nutritional composition across ten different formulations. Protein content ranged from 2.49 per cent to 2.79 per cent, fat from 2.09 per cent to 2.24 per cent, starch from 71.03 per cent to 72.95 per cent, crude fibre from 2.77 per cent to 3.08 per cent, and ash from 1.91 per cent to 2.49 per cent. These variations were influenced by tannia concentrations, which varied from 50 per cent to 80 per cent, and feed moisture levels, which ranged between 14 per cent and 18 per cent. An increase in tannia content generally led to higher levels of all measured nutrients, except protein. Conversely, raising the feed moisture content slightly lowered nutrient concentrations, likely due to a dilution effect caused by the reduction in total solids, which is evident in the final extruded product. These findings are consistent with earlier studies by Otegbayo (2002) [12] reported a decrease in protein content with the addition of plantain flour, and Gbenyi *et al.* (2016) [4] observed similar nutrient reductions in corn-sorghum extrudates with higher feed moisture levels.

Moisture content is a critical factor in extruded snacks, as it significantly affects texture, crispness, overall quality, and shelf life. In this study, the moisture content of tannia-based extrudates ranged between 2.65 per cent and 3.45 per cent. The highest moisture level was recorded in the formulation containing 75 per cent tannia and 18 per cent feed moisture. Among the variables, feed moisture had a greater influence on the final moisture content than the tannia concentration. An increase in feed moisture during processing led to a corresponding rise in the moisture content of the finished product.

Bulk density, expressed in grams per cubic centimeter (gcm⁻³), represents the mass of a substance relative to its volume. It plays an important role in packaging efficiency, as it influences how much product can be packed into a given space, thereby impacting storage and transportation costs. In

this study, the bulk density of tannia-based extrudates ranged from 0.09 to 0.16 gcm⁻³. Among the processing variables, feed moisture content had a more pronounced effect on bulk density than the proportion of tannia used. An increase in moisture content resulted in higher bulk density, indicating a positive relationship. This is likely due to improved particle cohesion and a reduction in air pockets within the product matrix, leading to a more compact structure. These observations are consistent with findings by Badrie and Mellows (1991)^[2] and Stojceska *et al.* (2009)

^[17], who also reported increased bulk density in extrudates made from cassava and from corn starch blended with red cabbage as moisture levels increased.

In this study, the enhanced appearance and texture of the extruded product contributed to its higher sensory scores for overall acceptability. Among the various formulations, treatment T₄ comprising 65per cent tannia flour and 16per cent moisture achieved the highest average score for overall acceptability. These results align with those reported by Reddy *et al.* (2014)^[13].

Table 2: Effect of different levels of tannia flour and feed moisture levels on nutritional and physical parameters of tannia based extruded snack

Treatments	Protein (%)	Fat (%)	Starch (%)	Crude fibre (%)	Ash (%)	Moisture content (%)	Bulk density(gcm ⁻³)
T ₁	2.77	2.10	71.26	2.83	2.13	2.75	0.09
T ₂	2.60	2.17	72.35	3.01	2.32	2.65	0.10
T ₃	2.68	2.13	71.66	2.94	2.23	3.09	0.11
T ₄	2.73	2.15	72.02	2.98	2.27	3.12	0.11
T ₅	2.71	2.12	71.61	2.95	2.24	2.77	0.09
T ₆	2.52	2.21	72.85	3.06	2.44	3.45	0.16
T ₇	2.54	2.19	72.55	3.03	2.42	3.43	0.16
T ₈	2.79	2.09	71.03	2.77	1.91	3.25	0.14
T ₉	2.49	2.24	72.95	3.08	2.49	3.21	0.12
T ₁₀	2.70	2.11	71.50	2.91	2.19	3.11	0.11

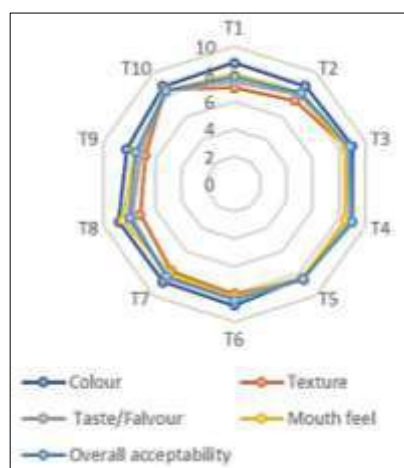


Fig 1: Sensory evaluation (9-point hedonic scale) of tannia based extruded snack

4. Conclusion

Flour combination of Tannia flour (65%), Moisture (16%) were used as the base flour combination for the development of the fortified tannia based extruded snack at standardized barrel temperature of 50 °C, 85 °C and 110 °C. Fitting of response model showed that tannia concentration of 74.67 per cent with 17.17 per cent moisture is capable of giving better results with desirable physico-chemical properties. Consumer acceptance testing and market feasibility studies should be conducted to evaluate preferences, pricing, and potential commercialization opportunities.

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