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Optimization of Maize Flour, Whey Protein Concentrate (WPC) and Ragi Flour in Extruded Snack Food

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A B S T R A C T

The present investigation was carried out to optimize the levels of maize flour, ragi flour, and whey protein concentrate (WPC) for the development of nutritionally enriched extruded snack food using extrusion cooking technology. Extrusion cooking is a high-temperature short-time processing method widely used for snack food production due to its versatility, low processing cost, and ability to produce acceptable ready-to-eat foods. Composite flour consisting of maize flour, rice flour, ragi flour, and WPC was utilized for preparation of extruded snack products. Response Surface Methodology (RSM) using Central Composite Rotatable Design (CCRD) was applied for optimization of ingredient levels. Sensory, textural, and physical characteristics such as flavour, texture, expansion ratio, hardness, and bulk density were evaluated. Results indicated that incorporation of maize flour (50–60%), ragi flour (5–15%), and WPC (5–10%) significantly influenced the quality characteristics of extruded snacks. The optimized product exhibited improved nutritional quality, better expansion, acceptable texture, and enhanced protein content. The study demonstrated that maize flour, ragi flour, and WPC can successfully be utilized for preparation of protein-rich functional extruded snack foods.

Introduction

Extrusion cooking is an important food processing technology extensively used for the manufacture of ready-to-eat snack foods, breakfast cereals, baby foods, and pet foods. It is a high-temperature short-time process that improves digestibility, enhances product quality, and reduces microbial load in foods.

Extrusion technology offers several advantages such as versatility, continuous production, low processing cost, and absence of process effluents. Snack foods have become a substantial part of the daily diet due to convenience, affordability, and consumer preference. However, conventional snack foods are often low in protein and dietary fibre.

Therefore, incorporation of nutritionally rich ingredients such as ragi flour and whey protein concentrate can improve the nutritional profile of extruded snacks.

Maize is widely used in extrusion processing because of its good expansion characteristics, pleasant flavour, and starch content. Ragi (finger millet) is a rich source of calcium, dietary fibre, minerals, and antioxidants. Whey protein concentrate (WPC) is a high-quality milk protein

ingredient containing essential amino acids and excellent functional properties. Incorporation of WPC into cereal-based snacks enhances protein quality and nutritional value. The present study was undertaken to optimize the levels of maize flour, ragi flour, and WPC in extruded snack food using Response Surface Methodology.

Materials and Methods

Raw Materials

The raw materials used in the study included maize flour, rice flour, ragi flour, whey protein concentrate (WPC-80), paneer whey, and salt. Maize flour and ragi flour were procured from the local market. WPC-80 containing 80% protein was used as the protein source

Preparation of Flour Blend

The composite flour blend consisted of maize flour, ragi flour, rice flour, and WPC. Rice flour was added by difference to make the total flour blend 100%. Salt was incorporated at 1–2% level. The flour blend was thoroughly mixed and conditioned before extrusion processing.

Experimental Design

Central Composite Rotatable Design (CCRD) under Response Surface Methodology (RSM) was employed to optimize the levels of:

Maize flour: 50–60%
Ragi flour: 5–15%
WPC-80: 5–10%

Twenty experimental runs were conducted.

Proximate Composition of Raw Materials

The proximate composition of raw materials used in preparation of extruded snack food is shown below.

Table.1 Experimental Design Matrix for Optimization

Run	Maize flour (%)	Ragi flour (%)	WPC -80 (%)
1	63.40	10	7.5
2	55	10	3.2
3	55	10	7.5
4	50	15	5
5	60	5	5
6	50	5	10
7	60	15	10

Table.2 Proximate Composition of Raw Materials

Proximate composition					
Constituent (%)	**Corn flour**	**Rice flour**	**Ragi flour**	**Whey***	**WPC-80***
Moisture	9.90±0.40	10.90±0.16	10.50±0.13	94.10±0.5	5.5±0.3
Protein	11.00±0.25	7.00±0.2	6.33±0.36	0.30 ± 0.02	80.40±0.06
Fat	3.75±0.05	0.74±0.16	1.08±0.24	0.58 ± 0.04	4.20±0.16
Carbohydrate	74.10±0.50	81.11±0.10	64.79±0.49	-	-
Lactose	-	-	-	4.52 ±0.08	5.60±0.06
Ash	1.25±0.06	0.25±0.05	1.91±0.14	0.50 ± 0.02	4.20±0.30
TS	89.16±0.36	90.24±0.17	90.38±0.10	5.80 ± 0.05	95.30±0.4
***In case of whey and WPC-80, carbohydrate is exclusively made up of lactose** ***Each observation is a mean ± SD of three replicate experiment (n=3)**					

Table.3 Sensory and Physical Characteristics of Optimized Product

Parameter	Value
Flavour Score	8.14
Texture Score	8.15
Overall acceptability	8.25
Expansion ratio	3,91
Bulk density (g/cm)	0.116

Results and Discussion

The sensory, textural, and physical characteristics of the extruded snack products were significantly affected by the levels of maize flour, ragi flour, and WPC. Products with higher maize flour showed better expansion and crispness due to higher starch content.

Increasing ragi flour improved mineral and fibre content but reduced expansion ratio at higher levels. WPC addition enhanced protein content but excessive addition negatively affected texture and expansion.

The optimized formulation exhibited:
Improved sensory acceptability
Higher protein content
Better expansion ratio
Lower bulk density
Crisp texture

The overall acceptability score ranged from 7.10 to 8.25 on a 9-point hedonic scale.

The study concluded that maize flour, ragi flour, and whey protein concentrate can successfully be utilized for preparation of nutritionally enriched extruded snack food. Optimization using Response Surface Methodology indicated that incorporation of maize flour (55–60%), ragi flour (5–10%), and WPC (5–10%) produced snack products with desirable sensory, physical, and nutritional properties. The developed product showed improved protein content, acceptable texture, and better expansion characteristics. Therefore, extrusion cooking technology can effectively be utilized for development of functional snack foods with enhanced nutritional quality.

Author Contributions

Arunkumar: Investigation, formal analysis, writing—original draft. Amitkumar Manojbhai Patel: Validation, methodology, writing—reviewing. Niranjan:—Formal analysis, writing—review and editing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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