

Value Addition of Foxtail Millet in Traditional Khakhra

B. Bhavani¹ and Shruti Kabra²

¹Student, Department of Food and Nutrition,

²Assistant Professor, Department of Food and Nutrition,
Veeranari Chakali Ilamma Women's University, Hyderabad, India

bharathapubbhavani04@gmail.com

Abstract: *The evolving global food landscape has increased demand for convenient, functional and nutrient-dense alternatives to time-intensive traditional foods. This study focused on the development and nutritional evaluation of a value-added traditional Indian snack, Khakhra, incorporated with foxtail millet (Setaria italica). Foxtail Millet Khakhra (FMK) was developed at two incorporation levels, 20% (Variation I) and 40% (Variation II), replacing an equivalent proportion of whole wheat flour. Twenty semi-trained panelists evaluated the sensory attributes of appearance, taste, odour, texture, colour and overall acceptability using a 5-point hedonic rating scale. FMK Variation I (20% incorporation) was found to be the most accepted formulation, yielding 12.1 g protein and 10.2 g dietary fibre as confirmed by AOAC nutrient analysis, compared with 11.3 g protein and 9.58 g fibre in the basic khakhra. One-way ANOVA revealed a statistically significant difference among the basic and variation formulations ($F_{\text{calculated}} = 3.345 > F_{\text{tabulated}} = 3.15$) at the 5% level of significance, although all formulations remained highly acceptable. Cost analysis showed only a marginal increase in production cost, from Rs.15/- for the basic khakhra to Rs.16/- and Rs.17/- for Variations I and II, respectively. The study concluded that foxtail millet can be effectively incorporated into khakhra to develop a nutritionally superior, cost-effective and consumer-acceptable traditional snack, offering a sustainable strategy to address malnutrition and lifestyle-related diseases.*

Keywords: Foxtail Millet, Khakhra, Value Addition, Sensory Evaluation, Nutrient Analysis, Cost Analysis

I. INTRODUCTION

Rapid urbanisation, changing lifestyles and the growing demand for convenient yet nutritious food have reshaped the global food landscape. Traditional foods, while culturally significant and nutritionally valuable, are often time-intensive to prepare, whereas convenience foods have gained popularity because of their ease of preparation and long shelf life. Among these, extruded and ready-to-eat products made from small millets are increasingly favoured for their fibre, protein and mineral content.

Foxtail millet (*Setaria italica*) is a climate-resilient, drought-tolerant nutri-cereal rich in protein (10-12%), dietary fibre (6-8%) and minerals such as iron, calcium and magnesium. It has a low glycaemic index (approximately 50-58) and is naturally gluten-free, making it suitable for individuals with diabetes and gluten intolerance. Despite these benefits, foxtail millet remains underutilised in daily diets owing to the limited availability of attractive, ready-to-eat value-added products.

Khakhra, a traditional thin, crispy roasted flatbread from Gujarat, is widely consumed across India but is conventionally prepared using refined wheat flour of comparatively lower nutritional value. Incorporating foxtail millet into khakhra can enhance its nutritional quality without compromising sensory acceptability, thereby promoting millet consumption, improving dietary quality and supporting nutritional security.



The present study was therefore undertaken to develop and standardise foxtail millet-incorporated khakhra, evaluate its sensory characteristics, estimate its nutritional composition with special reference to protein and dietary fibre, and assess its cost-effectiveness. The specific objectives were to: (i) formulate and develop khakhra incorporating foxtail millet; (ii) standardise the ingredients and method of preparation; (iii) calculate the nutrient composition and production cost; (iv) conduct sensory evaluation of the developed product; and (v) analyse the protein and fibre content of the basic and most accepted variation of the product.

II. MATERIALS AND METHODS

A. Procurement of Raw Material

Foxtail millet, Bengal gram (besan) flour, whole wheat flour, cumin seeds, oil and other spices required for product formulation were procured from the local market.

B. Formulation of Foxtail Millet Khakhra

Khakhra is a traditional thin, crispy roasted flatbread from Gujarat, made from whole wheat flour, oil, salt and spices, and commonly consumed with tea, curds or chutneys. The basic recipe was standardised using whole wheat flour, and foxtail millet flour was incorporated in two variations at 20% (Variation I) and 40% (Variation II), replacing an equivalent proportion of wheat flour. The ingredient composition is presented in Table I.

TABLE I. INGREDIENT COMPOSITION OF BASIC AND VARIATIONS OF KHA KHRA (PER SERVING)

Ingredient	Basic	Variation I	Variation II
Whole wheat flour	75 g	55 g	35 g
Besan flour	15 g	15 g	15 g
Foxtail millet flour	-	20 g	40 g
Kasuri methi	5 g	5 g	5 g
Cumin seeds	1/4 tsp	1/4 tsp	1/4 tsp
Red chilli powder	2 g	2 g	2 g
Turmeric, salt, oil, asafoetida, water	As required	As required	As required

Foxtail millet grains were washed, soaked for 6-12 hours, sun-dried for 2-3 hours and ground into flour before incorporation. The dough was kneaded, rolled thin and roasted on a hot tawa until crisp on both sides.

C. Nutritive Value Calculation

The energy, carbohydrate, protein, fat and fibre content of the basic and variation formulations were calculated using the Indian Food Composition Tables (IFCT, 2017) and Nutritive Value of Indian Foods (Gopalan et al., 2012).

D. Cost Analysis

The ingredient, labour and electricity costs for producing one serving of each formulation were recorded during procurement and processing to assess economic feasibility.

E. Sensory Evaluation

Sensory evaluation was conducted in the Department of Food and Nutrition, Veeranari Chakali Iamma Women's University, Hyderabad. Twenty semi-trained panelists assessed the products for appearance, taste, odour, texture, colour and overall acceptability using a 5-point hedonic rating scale, where 5 denoted "Excellent" and 1 denoted "Poor". Panelists rinsed their palate with water between samples.



F. Nutrient Analysis

The protein and dietary fibre content of the basic and most accepted variation of khakhra were estimated using standard AOAC methods.

G. Statistical Analysis

Sensory scores were compiled and analysed using one-way Analysis of Variance (ANOVA) to determine significant differences between the mean scores of the basic and the two variations, at the 5% level of significance.

III. RESULTS AND DISCUSSION

A. Nutritive Value of Khakhra

The calculated nutritive values of khakhra showed a slight decrease in carbohydrate and fibre content with increasing foxtail millet incorporation, accompanied by an increase in protein and fat content (Table II).

TABLE II. NUTRITIVE VALUE OF BASIC AND VARIATIONS OF KHA KHRA (PER SERVING)

Nutrient	Basic	Variation I	Variation II
Energy (kcal)	346.07	345.10	347.19
Carbohydrate (g)	60.65	59.81	59.16
Protein (g)	11.70	11.90	12.25
Fat (g)	5.50	5.63	6.43
Fibre (g)	10.69	10.02	9.35

B. Cost Analysis

The production cost of khakhra increased marginally from Rs.15/- (basic) to Rs.16/- and Rs.17/- for Variations I and II, respectively (Table III). The modest increase in cost relative to the nutritional gain confirms that foxtail millet incorporation is economically feasible for both household and small-scale commercial production.

TABLE III. COST ANALYSIS OF BASIC AND VARIATIONS OF KHA KHRA (RS. PER SERVING)

Cost Component	Basic	Variation I	Variation II
Ingredients	8	9	10
Labour	5	5	5
Electricity	2	2	2
Total (Rs.)	15	16	17

C. Sensory Evaluation of Khakhra

The basic khakhra received the highest scores for appearance, colour and overall acceptability, while sensory scores declined gradually with increasing foxtail millet incorporation (Table IV, Fig. 1). One-way ANOVA revealed a statistically significant difference among the three formulations ($F_{\text{calculated}} = 3.345 > F_{\text{tabulated}} = 3.15$, $p < 0.05$), consistent with Divakar and Prakash (2021), who reported darker colour and marginally lower sensory scores with increasing millet flour in khakhra. Nonetheless, all formulations remained within the highly acceptable range.

TABLE IV. MEAN SENSORY ATTRIBUTE SCORES OF KHA KHRA (BASIC AND VARIATIONS)

Attribute	Basic	Variation I	Variation II
Appearance	5.00	4.90	4.80
Colour	5.00	4.85	4.55



Attribute	Basic	Variation I	Variation II
Taste	4.70	4.60	4.50
Texture	4.75	4.65	4.65
Overall acceptability	4.90	4.60	4.55

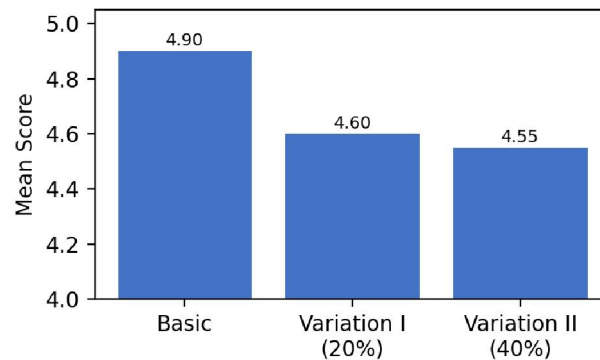


Fig. 1. Mean overall acceptability scores of khakhra (basic and variations)

D. Nutrient Analysis of Protein and Fibre

Laboratory (AOAC) analysis of the most accepted variation confirmed the calculated nutritive gains. Khakhra Variation I contained 12.1 g protein and 10.2 g dietary fibre, compared with 11.3 g protein and 9.58 g fibre in the basic khakhra (Table V). The analysed values were in close agreement with the calculated values, confirming good nutrient retention during processing and validating foxtail millet as an effective ingredient for enhancing the protein and fibre density of traditional khakhra.

TABLE V. ANALYSED PROTEIN AND DIETARY FIBRE CONTENT OF BASIC AND MOST ACCEPTED VARIATION OF KHA KHRA

Nutrient	Basic	Variation I
Protein (g)	11.3	12.1
Dietary fibre (g)	9.58	10.2

IV. CONCLUSION

Foxtail millet was successfully incorporated into traditional khakhra, producing a nutritionally superior, cost-effective and consumer-acceptable product. Khakhra Variation I (20% foxtail millet) was identified as the most accepted formulation, offering enhanced protein and dietary fibre content with only a marginal increase in production cost. The developed product can serve as a healthy alternative to conventional snacks, promoting millet consumption and contributing to improved nutritional security and the prevention of lifestyle-related diseases.

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