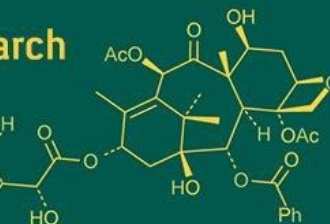
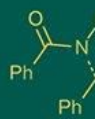


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Evaluation of production costs for fortified pasta enriched with skim milk powder and whole egg powder

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Abstract

The present study aimed to evaluate the production cost of fortified pasta made with WEP: whey protein and SMP: skim milk powder. The optimization studies predicted that 5% WEP and 10% SMP were best suited for the development of protein-rich pasta. The production cost of the fortified pasta was calculated based on the costs of raw materials, depreciation of equipment and machinery, labour charges, water and electricity expenses, rent, and maintenance costs. The break-even point, cost-benefit ratio, and return on investment were also assessed. The production costs for 1 kg of control and developed fortified pasta were Rs. 72.00 and Rs. 127.30, respectively. Additionally, the protein-rich fortified pasta is more nutritious compared to the control pasta.

Keywords: Fortified pasta, production cost, skim milk powder, whole egg powder

Introduction

In recent years, the demand for functional food products, including meat, eggs, and snack items, has surged as consumers increasingly prioritize health and wellness. These products are fortified with bioactive compounds, probiotics, vitamins, or minerals to provide benefits beyond basic nutrition, such as improved digestion, enhanced immunity, and better heart health (Wagh *et al.*, 2015) ^[10]. The growing awareness of preventive healthcare, along with busy lifestyles, has fuelled the popularity of functional snacks and protein-rich foods that offer convenience without compromising nutritional value (Jamadar *et al.*, 2025) ^[1]. As a result, food manufacturers are innovating to meet this demand, combining taste with functionality to appeal to health-conscious consumers seeking smarter dietary choices.

Pasta is a cereal-derived staple food and the second most widely consumed food worldwide, due to its low cost, nutritional composition, versatility, ease of preparation and storage, extended shelf life, as well as desirable sensory attributes (Kadam and Prabhasankar 2012) ^[7]. Pasta is a healthy food that is an important source of carbohydrates with virtually no fat (Foschia *et al.*, 2015) ^[2]. Pasta products are mainly made up of refined wheat flour, which is high in starch but low in protein and dietary fiber. Nowadays, it is essential to enhance the quality of pasta by fortifying it with other essential ingredients that possess proven nutritional benefits.

Pasta can be fortified with functional ingredients to enhance its nutritional quality, including essential amino acids, minerals, vitamins, and phenolic compounds. Fortifying pasta with protein-rich ingredients caters to health-conscious consumers who prefer products abundant in essential proteins, healthy lipids, and other health benefits (Kadam and Prabhasankar 2012) ^[7]. Several studies have evaluated the fortification of pasta with protein from various sources, including bean flour (Gallegos-Infante *et al.* 2010) ^[3] and shrimp meat (Ramya *et al.* 2015).

A modern active lifestyle necessitates the development of functional pasta for improved health and disease prevention, with careful selection and inclusion of food ingredients (Jamadar *et al.* 2022) ^[6]. There is significant potential for creating pasta products that offer health benefits. Semolina pasta is a widely consumed food, yet its biological value is low due to its protein being deficient in essential amino acids (Martínez-Villaluenga *et al.* 2010) ^[8]. However, if semolina is combined with other ingredients rich in these essential proteins from

milk, fish, eggs, and meat, not only are amino acids supplemented, but dietary vitamins and minerals can also be provided (Gull *et al* 2018) [5].

Eggs are rich in protein, fat, vitamins, and minerals with high biological value and are easily digested. Eggs are best protein source than milk. Egg proteins are a crucial source of amino acids and demonstrate versatile functional and biological value, approximately 100 percent. The proteins found in egg whites, such as ovalbumin, ovotransferrin, and lysozyme, contain hydrolysates that possess multifunctional properties, including antihypertensive, antioxidant, anti-inflammatory, and anti-diabetic effects (Garces-Rimon *et al* 2016) [4]. However, no studies have been reported on the fortification of pasta with SMP and WEP.

Milk proteins have long been recognized for their nutritional and technological value. They possess a high nutritional profile compared to other proteins due to their relatively high levels of essential amino acids and excellent digestibility (Meisel 1998) [9]. Caseins, which account for about 80% of the protein content in bovine milk, are extracted from milk through acid or rennet precipitation. These proteins are flexible, heat-stable, and contain a higher proportion of amino acids such as histidine, methionine, and phenylalanine. Fortifying pasta by replacing semolina with rich protein sources, such as whole eggs and casein, will not only enhance its nutritional value but also transform it into a functional food. Although significant efforts have been made to improve the functional properties and nutritional value of pasta through changes in formulations and processing, incorporating whole egg powder and milk

powder could usher in a new era of functional, protein-rich pasta foods. Consequently, this study has been proposed.

Materials and Methods

Source of raw materials

Semolina, skim milk powder, and whole egg powder were sourced from the local market in Ludhiana. These items were procured by verifying both the manufacture and expiry dates. The proximate composition of these raw materials was analyzed (Table 1). Packaging materials included LDPE (100 to 120 gauge) and aluminum foil-low-density polyethylene (LDPE) laminates, which were used for AP. Various analytical-grade reagents and compounds, along with culture and fine-grade performance standards, were employed to evaluate the quality of the items reviewed.

Table 1: Proximate composition of raw materials used

Proximate composition (%)	Semolina	Whole egg powder	Skim milk powder
Moisture	13.25±0.15	12.92±0.17	4.51±0.5
Protein	11.36±0.09	41.76±0.32	35.21±0.5
Fat	1.08±0.04	10.48±0.23	1.01±0.5
Ash	0.47±0.01	2.47±0.26	9.2±5.25

Preparation of fortified pasta

The formulation of the control and the developed fortified pasta was standardized based on a literature review and preliminary trials conducted in the laboratory. The standardized formulation is shown in Table 2.

Table 2: Formulations of the Control pasta and Developed fortified pasta

S. No.	Ingredients	Percentage (w/w)	
		Control pasta (%)	Developed fortified pasta (%)
1.	Semolina	100.00	85
2.	Water	90 mL	90 mL
3.	Whole egg powder	-	5
4.	Skim milk powder	-	10
	Total	100	100

Preparation of blends

Semolina was supplemented with whole egg powder and skim milk powder, as shown in Table 2, and weighed carefully. It was then subjected to the sieve twice to prepare the blends.



Fig 1: Pasta making machine (Kent Ltd, New Delhi)

Pasta preparation

The different formulations of whole egg powder and skim milk powder-enriched pasta were prepared by thoroughly mixing the ingredients in the mixing chamber of a pasta machine (Kent, New Delhi, India). An optimal amount of water (determined through preliminary trials) was added, and the mixture was kneaded for 8–10 minutes to ensure uniform hydration of the flour particles (Table 2). The dough was then extruded at a speed of 60 rpm (Fig. 1), with the extrusion temperature maintained between 37–40 °C. The extruded pasta was cut into 3 cm segments. Subsequently, the penne (tube-shaped) pasta was dried in an industrial dryer (MAC Industrial Dryer, New Delhi, India) at 50 °C for 4–5 hours. After drying, the pasta was packed in polyethylene bags and stored at 4 °C until further analysis. All product samples were coded, and sensory evaluations were conducted to assess the degree of liking or disliking based on a 9-point scale, using descriptive categories ranging from 'like extremely' to 'dislike extremely' (Larmond, 1973).

The economics of producing fortified pasta were calculated by considering all ingredients used in the preparation of the products, thus determining the most economically viable protein sources. RSM was used to standardize the level of

supplementation of two composition-coded/uncoded factors, namely WEP and SMP. The trials were designed using a Central Composite Design (CCD), resulting in 13 independent variable experimental designs.

Results and Discussion: The cost involved in preparing

each 1kg of fortified pasta, which includes the incorporation of WEP and SMP (Table 3), accounts for the cost, quantity, and approximate cost of raw ingredients such as semolina, whole egg powder, and skim milk powder. The total expenditure for the preparation of 1kg of fortified pasta was Rs 120.77, compared to normal pasta in the market.

Table 3: Cost of production of formulation ingredients

Ingredients	Quantity (g)	Rate (Rs/Kg)	Approx. Cost in rupees
Semolina	850	66	45.27
Whole egg powder	50	700	40.50
Skim milk powder	100	300	35
Total	1000		Rs 120.77

The formulation cost for 100 kg of control and developed fortified pasta is provided in Table 4. This cost includes raw ingredients such as semolina, WEP, and SMP for the developed fortified pasta, along with semolina for the

control pasta. The total expenditure accounts for both the quantity of raw materials and the cost of ingredients for both types of pasta.

Table 4: Preparation expense of 100 kg CP and DP

Ingredients	Rate Rs/kg	Control		Developed fortified pasta	
		Qt. (Kg)	Amount (Rs)	Qt. (Kg)	Amount (Rs)
Semolina	66	100.00	6600	85	5610.00
Whole egg powder	700		-	5	3500.00
Skim milk powder	300		-	10	3000.00
Total (Rs)	-	-	6600.00		12110.00

The cost analysis reveals that producing 100 kg of developed fortified pasta (DP) (Rs. 12,110) is significantly more expensive than control pasta (CP) (Rs. 6,600) due to the inclusion of high-value functional ingredients like whole egg powder (Rs. 3,500) and skim milk powder (Rs. 3,000), which enhance its protein and micronutrient content. Despite the 83.5% higher cost, the fortified pasta meets the growing consumer demand for nutritious, functional foods, enabling premium pricing and market differentiation.

The expense of overhead production for 100 kg of fortified pasta, which includes charges for labour and electricity.

a) Charges for labour

Under-skilled employee (Fivedaily paid workers) (Rs 220.00per day x 6) = Rs. 1320/-

b) Electricity charges

Table 5: Electricity charges

Equipment	Watt x hrs.	KWH Unit
Pasta maker (5No.s)	2 x 200 x 24	9.60
Industrial dryer (2No.s)	2000 x 15.00	30.00
Packaging machine	100 x 2.0	0.20
Light, fan etc.	400 x 10	4.00
Total		Rs 43.8

Electric cost (Rs 6/Unit) (43.8x Rs. 6.0) =262.80

c. Total equipment depreciation amounted to Rs 1,17,000/-, which primarily included the pasta maker, sealing machine, and industrial dryer, costing Rs 12000.00/-, Rs 5000.00/-, and Rs 100000.00/-.

Table 6: Other expenditures

Devaluation at a rate of 10% per year	Rs 11700/-
Depreciation expense per day	Rs 40.27
a) Charges for water supply(1000 litres)	Rs 10/day
a) Material charge of packaging (pack 250g each)	Rs. 240.00
b) (8"x6" Alum-LDPE Pouches @ Rs 0.6/pouch) (400 x 0.60)	
b) Rental cost for a room (Rs 3000 per month)	Rs.120.00 per day
c) Miscellaneous	Rs.250.00 per day
The overall amount of expenditures (a + b + c + d)	Rs.620.00/-

Table 7: Production cost control and developed fortified pasta

The total cost of 100 Kg formulation production	
Total cost of production of control pasta =(A) + (E) =6600+620 = Rs.7220/-	
Total cost of production of developed fortified pasta = (B) + (E)= Rs. 12110 + 620= Rs. 12730.00/-	

The cost of production for 1 kg of control and developed fortified pasta was Rs. 72.00 and Rs. 127.30, respectively. Furthermore, the protein-rich fortified pasta is more nutritious compared to the control pasta.

Conclusion

The results indicated that the production cost of control pasta was Rs. 72.00 per kg, while the developed fortified pasta had a higher production cost of Rs. 127.30 per kg.

Despite the increased cost, the fortified pasta offers superior nutritional value, including added functional ingredients that respond to the growing demand for health-beneficial foods. Considering the rising consumer preference for functional and fortified food products, the higher production cost is justified by the potential for premium pricing and increased market demand. Furthermore, the growing health consciousness and consumers' willingness to pay more for nutritious alternatives further bolster the economic viability of this product. Thus, the development of fortified pasta represents a promising and profitable start-up business opportunity in the expanding functional food market. Strategic marketing that highlights its health benefits, along with targeted distribution channels, can further enhance its commercial success, making it a sustainable and lucrative venture for entrepreneurs.

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