



Supplementary Information (SI)

Quality parameter protocols

pH of meat products was measured using a digital pH meter [39]. pH electrode was calibrated with standard buffer (pH 4 and pH 7) before measuring the pH of the meat samples.

Determination of Fat content

Fat content in meat samples was examined as per Association of Official Analytical (AOAC) [40]. The percentage of fat was determined by extracting 5 g of meat nuggets with petroleum ether for 6–8 h in a Soxhlet apparatus. The solvent was evaporated at 60 °C in a rotavapor. After heating fat content remains in the flask, an increase in the weight of tarred flask after evaporation of petroleum ether shows the weight of fat.

$$Fat \ content(\%) = \frac{\text{Increase in the weight of the flask}}{\text{weight of sample}} \times 100$$
(1)

Determination of Moisture

The moisture content was estimated by the standard Association of Official Analytical (AOAC) [40] method. Meat nuggets samples (5 g) were incubated in a hot air oven for 6–7 h at 100 °C in a Petri plate. Finally, dried meat samples were cooled in a desiccator for 15–20 min and weighed.

The moisture value of the meat samples was as below.

$$Moisture \ content(\%) = \frac{W1 - W2}{W1 - W} \times 100$$
(2)

where W = weight of empty dish, W1 = weight of dish before drying, and W2 = weight of dish after drying.

Determination of Crude Fiber Content

Crude fiber was determined as per the standard Association of Official Analytical [40]. Briefly, 2 g of dried fat free meat nugget samples was transferred to 500 mL conical flasks. 200 mL of 1.25% sulphuric acid was boiled and added to the sample flask. Contents were then boiled (for 30 minutes) and filtered through an ashless filter paper. This was followed by washing with boiling water. Then, 12.5% of NaOH was mixed with the residue in the filter paper, contents were then boiled (for 30 minutes) and again filtered through ashless filter paper. The residue was washed with boiling water and dried in a hot air oven at 105 ± 1 °C and weighed intermittently until varying stopped. Contents were then kept in muffle furnace at 550 °C for ashing. After ashing, the crucible was cooled in a desiccator and reweighed.

Percentage of crude fiber was determined by the following formula:

$$Crude \ Fiber(\%) = \frac{W1 - W2}{W} \times 100$$

where,

W = weight of sample

W1 = weight of the crucible + weight of treated sample after oven drying, and

W2 = weight of the crucible + weight of sample after ashing.

Determination of Ash Content

The meat nuggets sample (5 g) was transferred in silica dishes and incinerated over a Bunsen burner. After, it was kept in a muffle furnace at 525 °C for 6 h, cooled in dishes, and weighed. The total ash content was measured by the given formula and expressed as a percentage [40].

Ash
$$content(\%) = \frac{Final weight of ash}{Initial weight of sample} \times 100$$
 (4)

Energy Calculation

The total energy values (kcal/100 g) were determined using values of fat (9 kcal/g), protein (4 kcal/g), and carbohydrate (4 kcal/g).

Carbohydrates

Carbohydrates were estimated according to following formula: 100 - (moisture (%) + crude fiber (%) + ash + protein (%) + fat (%).

Sensory Evaluation

The overall acceptability of meat products was determined as per Meilgaard, Carr & Civille [41]. The developed samples were evaluated by semi-trained panelists comprising of postgraduate students and faculty members of the food technology department Jamia Hamdard, New Delhi, India, who evaluated the sensory quality of overall acceptability. These formulated meat nuggets were evaluated using the 9-points hedonic scale test (Wichchukit & O'Mahony [42]), varying from 9 as extremely like to 1 as extremely dislike.

In Vitro Human Digestion Model

Goat meat sample was digested in vitro following the previously developed protocol used by Hur, Decker, & Mc Clements [37], Versantvoort et al. [38] and INFOGEST with some modifications.

Initial stage: the sample consisted of control and functional meat nuggets.

- 1. In the mouth: meat nuggets (5 g) were dissolved in 6 mL of simulated saliva solution of pH 6.8 and were then stirred at 37 °C for 5 minutes.
- 2. In the stomach: simulated gastric juice (12 mL) at pH 2 was added and stirred at 37 °C for 2 hours.
- 3. In small intestine: duodenal juice (12 mL) + bile juice (6 mL) + HCO₃ (2 mL) solution of pH 6.5 to 7 was then added, and the mixture was stirred at 37 °C for 2 hours.

The concentration of various simulated fluids of the in vitro digestion protocol was prepared as described in Table 1 SI. All enzymes and chemicals used in the present study were procured from Sigma Aldrich. During the in vitro digestion model, the sample was swirled (60 RPM) on a shaking water bath used to simulate the motility of the gastrointestinal tract.

	Saliva	Gastric juice	Duodenal juice	Bile juice
Inorganic components	10 mL KCl 89.6 g/L 10 mL KSCN 20 g/L 10 mL NaH2PO4 88.8 g/L 10 mL NaSO4 57 g/L 1.7 mL NaCl 175.3 g/L 20 mL NaHCO3 84.7 g/L	15.7 mL NaCl 175.3 g/L 3.0 mL NaH2PO4 88.8 g/L 9.2 mL KCl 89.6 g/L 18 mL CaCl2·2H2O 22.2 g/L 10 mL NH4Cl 30.6 g/L 6.5 mL HCl 37%g/g	40 mL NaCl 175.3 g/L 40 mL NaHCO3 84.7 g/L 10 mL KH2PO4 8 g/L 6.3 mL KCl 89.6 g/L 10 mL MgCl2 5 g/L 180 μL HCl 37%g/g	30 mL NaCl 175.3 g/L 68.3 mL NaHCO3 84.7 g/L 4.2 mL KCl 89.6 g/L 150 μL HCl 37%g/g
Organic components	8 mL urea 25 g/L	10 mL glucose 65 g/L 10 mL glucuronic acid 2 g/L 3.4 mL urea 25 g/L 10 mL glucosamine hydro- chloride 33 g/L	4 mL urea 25 g/L	10 mL urea 25 g/L
Add to mixture of organic+ inor- ganic components	290 mg α-amylase 15 mg uric acid 25 mg mucin	1 g BSA 2.5 g pepsin 3 g mucin	9 mL CaCl2·2H2O 22.2 g/L 1 g BSA 9 g pancreatin 1.5 g lipase	10 mL CaCl2·2H2O 22.2 g/L 1.8 g BSA 30 g bile
pH	6.8 ± 0.2	1.30 ± 0.02	8.1 ± 0.2	8.2 ± 0.2
ne	For all inorganic cessary, pH of the j	e and organic solutions, dis juices was adjusted to the a	stilled water was ado ppropriate level.	ded up to 500 mL. If

Table S1. The concentration of various synthetic juices of the in vitro human digestion model presented in the table.

Table S2. Comparison of nutritional quality of functionally optimized products with control (one & two).

								Choles	sterol	ТВА	RS
Products	pН	Moisture	fat Ash	CF	OA	Energy	CHO	Before in	After in	Before in	After in
								vitro	vitro	vitro	vitro
Control-one	6.40	53.82	4.9 3.2	0.52	9	192.44	19.83	48.90	41.27	0.13	0.25
Control-two	6.45	62.48	5.8 3.8	0.54	9	171.57	8.57	52.47	46.47	0.16	0.31
Optimized											
Functional	6.68	50.35	3.5 3.5	2.7	8.33	192.38	25.62	48.5	35.24	0.11	0.15
nuggets											





Contour Plot of Moisture content vs Goat Meat (g), Psyllium husk (g)



(b)



(c)

Figure S1. (a) Contour plot of moisture content (%) vs. fenugreek leaves (g), goat meat (g). (b) Contour plot of moisture content (%) vs. goat Meat (g), psyllium husk (g). (c) Contour plot of moisture content (%) vs. fenugreek leaves (g), psyllium husk (g).





(b)



Figure S2. (a) Contour plot of ash content (%) vs. goat meat (g), fenugreek leaves (g). (b) Contour plot of ash content (%) vs. goat meat (g), psyllium husk (g). (c) Contour plot of ash content (%) vs. fenugreek leaves (g), psyllium husk (g).



(a)



(b)



(c)

Figure S3. (a): Contour plot of crude fiber (%) vs. goat meat (g), fenugreek leaves (g). (b) Contour plot of crude fiber (%) vs. goat meat (g), psyllium husk (g). (c) Contour plot of crude fiber (%) vs. fenugreek leaves (g), psyllium husk (g).





(b)



(c)

Figure S4. (a): Contour plot of overall acceptability (OA) vs. goat meat (g), fenugreek leaves (g). (b) Contour plot of overall acceptability (OA) vs. goat meat (g), psyllium husk (g). (c) Contour plot of overall acceptability (OA) vs. fenugreek leaves (g), psyllium husk (g).

Table S3. Response optimizer module.

Response Optimization: Fat (%)

Response	Goa	l Lower	Target	Upper	Weight	Importance
Fat (%)	Minim	num	3	7	1	1
	Starting	g Values				
			Variable			Setting
		(Goat meat (g)			60
		Fenu	ıgreek leaves (g	;)		6
		Psy	/llium husk (g)			3
	Solutio	n				
	Goat Meat	Fenugreek	Psylliun	n	Fat (%)	Composite
	(g)	Leaves (g)	Husk (g		Fit	Desirability
1	51,5910	5.23555	6.36359)	3.87092	0.782270

Multiple Response Prediction

Variable	e		Setting	-
Goat Meat	(g)			
Fenugreek lea	ves (g)			
Psyllium hus	sk (g)		6.36359	
Response	Fit	SE Fit	95% CI	95% PI
Fat (%)	3.871	0.174	(3.497, 4.245)	(3.419, 4.323)

Constituents	Optimized Functional Nuggets (g)	Control-one (g)	Control-two (Weight Conserved Nuggets, g)
Goat meat	51.6	51.6	63.1
FL (Fenugreek Leaves)	5.2	-	-
PH (Psyllium Husk)	6.3	-	-
Salt	2	2	2
Condiment (onion: ginger: garlic)	6 (3:1.5:1.5)	6 (3:1.5:1.5)	6 (3:1.5:1.5)
Green chili	3	3	3
Spices	6	6	6
Ice	10	10	10
Oil	2	2	2
Soybean flour	6.9	6.9	6.9
Turmeric powder	1	1	1

 Table S4. Composition of optimized and control nuggets.