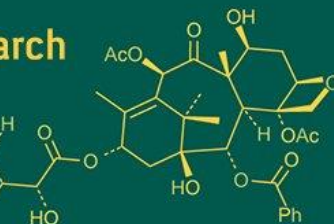
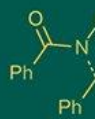


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Effect of fenugreek leaves powder on physicochemical, antioxidant and sensory properties of marinated broiler chicken

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Abstract

An experiment was conducted to determine the optimum level of fenugreek leaves powder incorporation in the marinade for marinated broiler chicken. Fenugreek leaves powder was incorporated into a standardized basic marinade at 1.5, 2.5 and 3.5% levels, along with a control without fenugreek leaves powder. The marinated broiler chicken samples were evaluated for physico-chemical characteristics, antioxidant properties and sensory quality. The pH of fresh marinated meat and cooked product increased significantly ($P < 0.001$) with increasing levels of fenugreek leaves powder. Cooking yield, moisture retention, marination retention and marination yield also increased significantly ($P < 0.001$) with increasing levels of fenugreek leaves powder. Water holding capacity of fresh and cooked products and drip loss did not differ significantly among treatments. DPPH inhibition, total phenolic content and reducing power increased significantly ($P < 0.001$) with increasing levels of fenugreek leaves powder. Sensory scores for appearance and colour, flavour, juiciness, tenderness, texture and overall acceptability improved with fenugreek incorporation up to 2.5%, followed by a decline at 3.5%. Among the treatments, marinated chicken containing 2.5% fenugreek leaves powder recorded the highest overall acceptability score. Therefore, 2.5% fenugreek leaves powder was selected as the optimum level for incorporation in the marinade for marinated broiler chicken.

Keywords: Fenugreek leaves powder, marinated chicken, herbal marinade, antioxidant activity, DPPH, total phenolic content, broiler chicken

Introduction

Chicken meat is widely consumed because of its high-quality protein, favourable nutritional characteristics and versatility in preparation. Marination is an important processing technique used in poultry meat to improve flavour, tenderness, juiciness and overall sensory quality. Marinades generally contain salt, spices, herbs, oil and other functional ingredients that facilitate flavour development and improve the technological properties of meat. The increasing consumer interest in natural and healthier meat products has encouraged the use of herbs and plant-derived ingredients as functional components in meat processing. Natural herbs are rich in phenolic compounds, flavonoids and other bioactive constituents that possess antioxidant and antimicrobial properties. Incorporation of such herbs into meat products may improve their functional characteristics while reducing dependence on synthetic additives.

Fenugreek (*Trigonella foenum-graecum*) is an important culinary herb widely used in Indian food preparations. Fenugreek leaves are rich in alkaloids, flavonoids, salicylates, nicotinic acid and polyphenols. The leaves also contain appreciable levels of phenolic compounds and tocopherols, which contribute to their antioxidant potential. Devatkal *et al.* (2011)^[5] reported considerable phenolic content and free radical scavenging activity in fenugreek leaves extract. Ahmad and Saleh (2019)^[2] also reported improved flavour, tenderness, juiciness and overall acceptability in beef patties incorporated with fenugreek leaves powder.

The functional properties of fenugreek may also influence the technological quality of meat products. Its soluble fibre, galactomannan and mucilaginous components possess water-binding and thickening properties, which may contribute to improved moisture retention, marination uptake and cooking yield. Fenugreek has therefore attracted attention as a potential natural functional ingredient for meat products.

However, the optimum level of fenugreek leaf powder in a standardized herbal marinade for broiler chicken has not been adequately established. Therefore, the present study was undertaken to determine the optimum level of fenugreek leaves powder in the marinade for marinated broiler chicken based on physico-chemical, antioxidant and sensory characteristics.

Materials and Methods

Raw materials

Live broiler chickens were procured from the local market and slaughtered following standard operating procedures at the Department of Livestock Products Technology, Veterinary College and Research Institute, Orathanadu. External fat, skin and connective tissues were removed manually. Breast and thigh portions were separated and chilled at 4 °C for 2 h. The meat was then cut into approximately 50 g pieces measuring 10 × 5 × 1 cm.

Preparation of fenugreek leaf powder

Fresh fenugreek leaves were collected from the Institute Herbal Garden, Ethno Veterinary Research and Development Centre, Veterinary College and Research Institute, Orathanadu. The leaves were thoroughly washed with potable running water and shade-dried for 2-4 days. Subsequently, the leaves were dried in a hot-air oven at 60 °C for 5-6 h. The dried leaves were ground using a mixer and sieved through a fine mesh to obtain a fine powder. The powder was packed in sterile polyethylene pouches and stored under refrigeration until further use.

Preparation of spice mix

The spice mix consisted of aniseed (10%), black pepper (10%), red chilli (13%), caraway seed (10%), cardamom (2%), cinnamon (5%), cloves (5%), coriander (20%), cumin seeds (10%), dried ginger (10%) and turmeric (5%). The ingredients were cleaned, dried at 50 °C for 4 h, ground and sieved before blending.

Formulation of basic marinade

A standardized basic marinade was prepared using salt (2.5%), onion powder (2.0%), garlic powder (1.0%), ginger powder (1.0%), dry spice mix (2.5%), Kashmiri chilli powder (1.0%), vegetable oil (5.0%) and water (20.0%). The basic marinade ingredients and the required quantity of fenugreek leaves powder were homogenized in water and oil to obtain a uniform marinade.

Table 1: Formulation of fenugreek leaves powder incorporated marinade for broiler chicken

Ingredients (%)	Control	Level of fenugreek leaves powder		
		T ₁	T ₂	T ₃
Chicken meat	100	100	100	100
Fenugreek levels powder	-	1.5	2.5	3.5
Salt	2.5	2.5	2.5	2.5
Onion powder	2.0	2.0	2.0	2.0
Ginger powder	1.0	1.0	1.0	1.0
Garlic powder	1.0	1.0	1.0	1.0
Dry spice mix	2.5	2.5	2.5	2.5
Kashmiri chilli powder	1.0	1.0	1.0	1.0
Vegetable oil	5.0	5.0	5.0	5.0
Water	20	20	20	20

Preparation of marinated broiler chicken

Fresh breast and thigh portions were cut into approximately 50 g pieces. The required quantity of marinade was thoroughly mixed manually with the chicken pieces. The marinated samples were packed in LDPE pouches and stored at 4 ± 1 °C for 2 h. Six trials were conducted. For sensory evaluation, an electric hot-air convection oven preheated to 180 °C was used. Cooking was standardized for 40 min and the internal temperature of the chicken was maintained at approximately 75 °C.

Analytical procedures

Physico-chemical quality

The pH of fresh marinated chicken and cooked products was determined by homogenizing 10 g sample with 50 mL distilled water for 1 min and measuring with a calibrated digital pH meter. Marination yield was calculated from the weight of meat before and after marination. Marination retention was determined after storage at 4 ± 1 °C for 24 h. Water holding capacity was determined according to Wardlaw *et al.* (1973) [12]. Cooking yield was calculated from the weight before and after cooking, while moisture retention was calculated according to El-Magoli *et al.* (1996) [6]. Drip loss was determined after 24 h storage at 4 ± 1 °C.

Antioxidant properties

Total phenolic content was determined by the Folin-Ciocalteu method and expressed as mg gallic acid equivalents (GAE)/g sample (Singleton *et al.*, 1999) [10]. DPPH radical-scavenging activity was determined using the DPPH assay and expressed as percentage inhibition (Blois *et al.*, 1958) [4]. Reducing power was estimated according to method described by Oyaizu (1986) [9].

Sensory quality

Sensory characteristics including appearance and colour, flavour, juiciness, tenderness, texture and overall acceptability were evaluated using a nine-point hedonic scale, where 9 represented extremely desirable and 1 represented extremely undesirable. A trained and semi-trained panel consisting of faculty members and postgraduate students of Veterinary College and Research Institute, Orathanadu, evaluated the samples.

Statistical analysis

Data generated from six trials were analyzed using SPSS version 20.0. Analysis of variance was performed following Snedecor and Cochran (1989) [11] and treatment means were compared statistically.

Results and Discussion

Physico-chemical characteristics

The results of physico-chemical characteristics of marinated broiler chicken incorporated with different levels of fenugreek leaves powder are presented in Table 2. The pH of fresh marinated meat increased significantly ($P < 0.001$) from 6.11 ± 0.01 in the control to 6.64 ± 0.01 in T₃. Similarly, product pH increased from 6.35 ± 0.01 in the control to 6.60 ± 0.01 in T₃. The higher pH of fenugreek-treated samples might be attributed to the presence of alkaloids, saponins and other nitrogenous compounds in fenugreek leaves. Similar observations were reported by Laila *et al.* (2024) [7] and Acharya *et al.* (2011) [1].

Cooking yield increased significantly ($P < 0.001$) from $77.94 \pm 0.45\%$ in the control to $84.50 \pm 0.69\%$ in T3. The increase might be due to the soluble fibre, galactomannan, mucilage and polyphenols in fenugreek leaves, which enhance water and fat binding during cooking. Ahmad *et al.* (2019) [3] reported that fenugreek galactomannan has strong water-binding properties and could improve moisture retention in meat products. Moisture retention increased significantly ($P < 0.001$) from $48.41 \pm 0.16\%$ in the control to $55.52 \pm 0.87\%$ in T3. This improvement might be attributed to the high water-holding capacity of fenugreek fibre and the formation of a hydrated gel by galactomannan. The higher pH at greater levels of fenugreek might reduce protein denaturation, thereby improving moisture retention.

Marination retention increased significantly ($P < 0.001$) from $89.59 \pm 0.27\%$ in the control to $95.75 \pm 0.17\%$ in T3. Similarly, marination yield increased from 91.42 ± 0.25 to $97.06 \pm 0.14\%$. The increased marinade retention might be attributed to the viscosity, binding properties and hydrophilic nature of fenugreek, which enhance marinade uptake. The mucilaginous fibre might further improve the adhesion of the marinade to the meat surface. Fresh WHC increased numerically from $32.64 \pm 0.48\%$ in the control to $45.22 \pm 1.24\%$ in T3, while product WHC increased from 37.00 ± 10.90 to $51.83 \pm 1.74\%$. However, the differences were not significant ($P > 0.05$). Drip loss decreased numerically from $3.27 \pm 0.04\%$ in the control to $2.86 \pm 0.15\%$ in T3, but the difference was also non-significant.

Table 2: Effect of incorporation of fenugreek leaf powder on physico-chemical and antioxidant characteristics of marinated chicken

Parameters	Level of fenugreek leaves powder in marinated chicken				P Value
	Control (0%)	T ₁ (1.5%)	T ₂ (2.5%)	T ₃ (3.5%)	
Physico-chemical parameters*					
pH (fresh)	6.11 ± 0.01 ^a	6.26 ± 0.08 ^a	6.44 ± 0.07 ^b	6.64 ± 0.01 ^b	0.0001***
Product pH	6.35 ± 0.01 ^a	6.41 ± 0.01 ^b	6.55 ± 0.03 ^c	6.60 ± 0.01 ^d	0.0001***
Cooking yield (%)	77.94 ± 0.45 ^a	79.27 ± 0.18 ^a	83.54 ± 0.26 ^b	84.50 ± 0.69 ^c	0.0001***
Moisture retention (%)	48.41 ± 0.16 ^a	52.29 ± 0.40 ^b	54.35 ± 0.91 ^c	55.52 ± 0.87 ^c	0.0001***
Marination retention (%)	89.59 ± 0.27 ^a	91.78 ± 0.21 ^b	93.82 ± 0.32 ^c	95.75 ± 0.17 ^d	0.0001***
Marination yield (%)	91.42 ± 0.25 ^a	93.16 ± 0.42 ^b	95.10 ± 0.50 ^c	97.06 ± 0.14 ^d	0.0001***
Water holding capacity (fresh) (%)	32.64 ± 0.48	40.16 ± 7.98	43.71 ± 0.63	45.22 ± 1.24	0.2194
Water holding capacity (product) (%)	37.00 ± 10.90	44.25 ± 3.52	49.26 ± 2.06	51.83 ± 1.74	0.2533
Drip loss (%)	3.27 ± 0.04	2.80 ± 0.30	3.02 ± 0.10	2.86 ± 0.15	0.2024
1, 1 diphenyl 2-picrylhydrazyl inhibition percent (DPPH) (%)	12.49 ± 0.54 ^a	61.10 ± 6.60 ^b	63.86 ± 3.35 ^b	75.70 ± 5.03 ^b	0.0001***
Total phenolic content (mg GAE/g)	0.62 ± 0.33 ^a	2.33 ± 0.08 ^b	2.52 ± 0.04 ^b	3.30 ± 0.16 ^c	0.0001***
Reducing power (%)	0.18 ± 0.01 ^a	0.42 ± 0.03 ^b	0.48 ± 0.03 ^b	0.49 ± 0.02 ^b	0.0001***

Number of observations: * n = 6; ($P < 0.05$); ($P < 0.001$) ***.

Means bearing different superscripts row-wise differ significantly ($P < 0.05$).

Antioxidant properties

DPPH inhibition increased significantly ($P < 0.001$) from $12.49 \pm 0.54\%$ in the control to $75.70 \pm 5.03\%$ in T3. The marked increase in radical-scavenging activity indicates the contribution of fenugreek phytochemicals to the antioxidant potential of marinated chicken. Total phenolic content increased significantly from 0.62 ± 0.33 mg GAE/g in the control to 3.30 ± 0.16 mg GAE/g in T3. This increase suggests that effective diffusion of fenugreek phenolic compounds into the meat matrix during marination. Devatkal *et al.* (2011) [5] reported 52.8 mg GAE/g phenolic content in fenugreek leaves extract, with 64.2% free radical scavenging activity. Naidu *et al.* (2011) [8] also reported substantial phenolic content and radical-scavenging activity in fenugreek extract. Reducing power increased significantly ($P < 0.001$) from $0.18 \pm 0.01\%$ in the control to $0.49 \pm 0.02\%$ in T3. The increase might be attributed to the electron-donating capacity of phenolic compounds and other antioxidant constituents present in fenugreek.

Sensory evaluation

The sensory results are presented in Table 3. All sensory attributes differed significantly ($P < 0.001$) among treatments. Appearance and colour scores increased from 7.61 ± 0.08 in the control to 8.34 ± 0.05 in T₂, followed by a decrease at 3.5% fenugreek leaves powder. The improved score at 2.5% might be attributed to the favourable colour and appearance resulting from the moderate incorporation of fenugreek. The decline at 3.5% might be associated with the stronger greenish-brown colour imparted by the herb. Flavour scores increased from 7.58 ± 0.07 in the control to 8.36 ± 0.07 in T₂. The improved flavour at the intermediate

level might be associated with the characteristic pleasant aromatic compounds present in fenugreek. At the highest level, the stronger herbal flavour and bitterness might have masked the characteristic flavour of chicken. Previous research has also reported improved flavour and other sensory attributes with moderate fenugreek incorporation. Juiciness increased from 7.74 ± 0.07 in the control to 8.39 ± 0.07 in T₂, which might be due to improved marinade uptake and moisture retention. Tenderness increased from 7.52 ± 0.07 to 8.50 ± 0.08 , while texture increased from 7.42 ± 0.10 to 8.36 ± 0.07 at 2.5%. Improved moisture retention and marinade absorption might have contributed to better tenderness and texture. At higher levels, excessive fibre content and stronger herbal characteristics might have reduced sensory quality.

Overall acceptability increased from 7.60 ± 0.10 in the control to 8.31 ± 0.11 in T₂, followed by a decline to 7.84 ± 0.07 in T₃. Thus, 2.5% fenugreek leaves powder provided the most favourable balance of sensory attributes. Although the 3.5% level produced the highest values for several physico-chemical and antioxidant parameters, the sensory scores declined at this level. The 2.5% treatment produced a desirable balance between technological functionality, antioxidant potential and sensory acceptability. It recorded $83.54 \pm 0.26\%$ cooking yield, $54.35 \pm 0.91\%$ moisture retention, $93.82 \pm 0.32\%$ marination retention, $95.10 \pm 0.50\%$ marination yield and an overall acceptability score of 8.31 ± 0.11 . Therefore, 2.5% fenugreek leaves powder was selected as the optimum level for incorporation into the marinade for marinated broiler chicken.

Table 3: Effect of incorporation of fenugreek leaves powder on sensory attributes of marinated chicken

Parameters	Level of fenugreek leaves powder in marinated chicken				P Value
	Control (0%)	T ₁ (1.5%)	T ₂ (2.5%)	T ₃ (3.5%)	
Sensory attributes**					
Appearance and colour	7.61 ± 0.08 ^a	8.02 ± 0.07 ^b	8.34 ± 0.05 ^b	7.80 ± 0.08 ^b	0.0001***
Flavour	7.58 ± 0.07 ^a	8.04 ± 0.09 ^b	8.36 ± 0.07 ^c	7.75 ± 0.08 ^b	0.0001***
Juiciness	7.74 ± 0.07 ^a	8.10 ± 0.09 ^b	8.39 ± 0.07 ^c	7.85 ± 0.08 ^b	0.0001***
Tenderness	7.52 ± 0.07 ^a	7.93 ± 0.10 ^b	8.50 ± 0.08 ^b	8.09 ± 0.09 ^b	0.0001***
Texture	7.42 ± 0.10 ^a	8.09 ± 0.07 ^b	8.36 ± 0.07 ^b	7.75 ± 0.10 ^a	0.0001***
Overall acceptability	7.60 ± 0.10 ^a	8.09 ± 0.09 ^b	8.31 ± 0.11 ^b	7.84 ± 0.07 ^c	0.0001***

Number of observations: ** n = 36; (P < 0.001) ***.

Sensory attributes of marinated chicken were evaluated on a 9-point hedonic scale (wherein 1 = extremely undesirable; 9 = extremely desirable).

Means bearing different superscripts row-wise differ significantly (P < 0.05).

Conclusion

The incorporation of fenugreek leaves powder in the marinade improved the physico-chemical and antioxidant characteristics of marinated broiler chicken. Increasing the level of fenugreek leaves powder significantly enhanced cooking yield, moisture retention, marination retention, marination yield, DPPH inhibition, total phenolic content and reducing power. However, sensory quality decreased at the highest incorporation level of 3.5%. Among the treatments, 2.5% fenugreek leaves powder was found to be the optimum level, providing the best overall sensory acceptability along with desirable technological and antioxidant properties.

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