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Effect of processing conditions on physico-chemical and textural properties of *shami kebab*

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Abstract

Effect of processing conditions like time and temperature of processing and methods of cooking on physico-chemical and textural attributes of *shami kebab* were studied. *Shami kebab* was deep fat fried at 120°C for 5 min and 170°C for 2 min and grilled at 140 and 180°C for 5 and 3 min respectively. Variation in cooking yield do not differ significantly ($p < 0.05$) at 120°C deep fat frying and 180°C grilling. Overall acceptability indicated highest as 8.01 at 170°C deep fat frying processing conditions. Deep fat frying has induced more moisture loss in the product affecting the visco-elastic behavior and the effect was evident in the springiness and cohesiveness profile. Gumminess behavior of all the *kebab* samples revealed a more energy requirement in complete disintegration. Lipid oxidation in terms of free fatty acid and thio-barbituric acid reactive substances ranged from 7.02 to 8.74% oleic acid and 0.38 to 0.68 mg/kg malonaldehyde respectively.

Introduction

Meat is known as the important source of protein, B vitamins and trace elements. Meat varieties appear in the diet of more people throughout the world. It is important in human diet because they provide well-some of the essential elements (Demirezen and Uruc, 2006). The major sources of animal proteins are beef, poultry, pork and mutton. Predominantly meat is available in the raw form in the markets however precooked and ready to eat convenient meat products are highly demanded by consumers because of ease in use and time saving. Important sensory characteristics of meat are appearance, juiciness, flavor and texture. Major processed meat products available in the market include meat balls, frankfurters, nuggets, steaks, patties and burgers. Mutton industry occupies a very important place in the agricultural sector in India and contributes significantly to the country's economy. With an annual output of 800 million sheep's and goats, India ranks sixth largest producer in the world (FAO, 2010). Mutton is a very good source of riboflavin, ascorbic acid and thiamin.

Thermal processing makes meat palatable and it imparts desirable attributes for consumers in terms of physical and sensory characteristics. As a result of thermal processing, connective tissues in meat will have a tenderizing effect while toughening effect is due to hardening of myofibrillar proteins (Laakkonen, 1973). Thermal processing of meat and meat products include open cooking, pressure cooking, fat frying, grilling, microwave, smoking etc. Shallow frying, sautéing, stir frying and deep-fat frying in vegetable oil or melted animal fats are the common methods of frying. Food frying is a common process in the food industry which is used to enhance the overall quality, texture and flavour of snack foods, doughnuts, French fries and poultry products (Chukwu, 2009). During frying process, the product's internal moisture is vaporized into steam and the product surface begins to dry, resulting in the formation of a crunchy crust on the outside as the plane of evaporation moves inside the food and hot fat begins to penetrate the food (Fellows, 2009). Even though frying and fried foods are very popular and widely accepted, the processing method has some adverse effects on the proximate compositions. Deep-fat frying is an important food processing operation that involves heat and mass transfer, inducing structural changes such as shrinkage (Wang *et al*., 2010) and normally carried out at high temperatures (160°C - 180°C). Exposure of frying oils and fats to air and moisture during frying process induces physical and chemical deterioration and affects frying performance and storage stability of fried products (Fauziah *et al*., 2000). In addition, highly oxidized oils may also produce polyaromatic hydrocarbons that are thought to have a carcinogenic effect (Rahman *et al*., 2007).

Deep fat fried (DFF) products are concentrated source of energy and essential fatty acids needed for the growth and development (Zeb and Ali, 2008). *Shami kebab* is a popular meat and pulses based

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DFF snack among Indian community. *Shami kebab* is usually made from the batter of minced mutton, chicken or beef with ground gram lentils paste, few vegetables and spices. It is a rich source of both vegetable and animal proteins. But in most of the cases, *shami kebab* stands for the preparation with minced mutton. When prepared fresh, it has a crispy texture with a pleasant spicy flavor. Recent trend points towards consuming convenient packaged foods and fried *shami kebab* can be a consumer choice in this category. Fried foods are among the favorites for people around the world and the market for fried foods remains very large and it continues to increase although there are health concerns associated with consuming high calorie foods therefore grilling of the *kebab* is also an important processing conditions. The purpose of this study was to find the effect of processing conditions on the physico-chemical and textural characteristics of *shami kebab.*

Material and Methods

Shami kebab dough was prepared using the standardized formulation (Table 1) and procedure using minced mutton, Bengal gram paste (from overnight soaked and thoroughly drained Bengal gram dhal), vegetables, spices and egg. The meat was minced in a high performance meat mincer (Sirman, TC22E-model, UK) and was mixed with the standardized quantities of spices and vegetables. Bengal gram dhal paste was added into the above mix and kneaded till the ingredients are uniformly mixed. The dough was made in to oval shaped *kebab* weighing 30 g each. They were subjected for two different processing techniques; DFF and grilling. Kebab was fried in deep fat fryer (Mini-master fryer, Continental, Bangalore, India) at 120°C and 170°C for 5 min and 2 min and grilled in a grill baking oven (Philips, HD4464/00-model, Goa, India) at 140°C and 180°C for 5 min and 3 min respectively to find out the sensory attributes and effect of processing conditions on the overall physico-chemical and textural characteristics. The time temperature combination was chosen so as the product was cooked properly.

Table 1. Ingredient formulation of *shami kebab* dough

Ingredients	Quantity (g/kg of *kebab* dough)
Minced mutton	520
Bengal gram dhal paste	160
Smashed full egg	50
Chopped onion	90
Green chilly	26
Garlic	15
Ginger	10
Red chilly powder	15
Turmeric powder	5
Ground cumin seed	5
Ground cardamom	2
Ground cinnamon	2
Refined sunflower oil	70
Salt	20

Proximate composition and lipid oxidation

Proximate composition with respect to moisture, protein, total fat as ether extract and total carbohydrate (by difference) were determined as per AOAC (1997). Oxidative rancidity and hydrolytic rancidity were analyzed with respect to free fatty acids (FFA) as % oleic acid (AOCS, 1972) and thio barbituric acid reactive substances (TBA) as mg malonaldehyde/kg (Tarladgis *et al*., 1960) respectively. All the chemicals used in the progress of this research analysis were of AR grade.

Cooking yield and moisture retention

Cooking yield was determined as per Serdaroglu (2006) by measuring the difference in sample weight before and after cooking. Moisture retention and fat retention were calculated according to El-Magoli *et al*. (1996). Different equations applied in the process as follows:

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked sample}}{\text{Weight of uncooked sample}} \times 100$$

$$\text{Moisture retention (\%)} = \frac{\text{\% cooking yield x \% moisture in sample}}{100}$$

Hunter color estimation

The color coordinate values L^*, a^*, b^* ('L'-lightness/darkness, 'a'-redness/green, 'b'-yellowness/blue) were measured (Shand, 2000) using D-65 Illuminant, with a spectral range 400 - 700 nm and a spectral resolution of 10 nm (Color Flex, CFLX-45-2, Hunter lab, Reston, USA). The photo sensor was standardized using standard black and white color tiles and the sample color values were read and recorded using Easy Match QC Software (Hunter Lab, Reston, USA).

Density, water activity (a_w) and pH

Density (ρ) of sample was measured based on Archimedes displacement principle in a medium sample cell with three runs taking the mean and standard deviation (SD) of 0.005% using Ultrapycnometer (Quantachrome Instruments, FL, USA) in flow mode at 1 kg/cm^2 supply of helium gas. Water activity of the sample was determined using a pre-equilibrium conditioned water activity meter (Labmaster-aw, Novasina, Switzerland) at 25°C. pH was determined by homogenizing 10 g of sample in 40 ml of double distilled water, filtered in Whatman no:41 paper and measured using digital pH meter (Cyber scan 510, Singapore).

Texture profile analysis

Texture profile analysis (TPA) of the samples was carried out using a 50 Newton (N) load cell connected to TA plus texture analyzer, (Lloyd instruments, Hampshire, UK). Two bite (two cycles) penetration tests at a constant pre and post-test speed of 30mm/min using a 4 mm ball probe at the geometric center of the kebab was performed. Other test parameters were maintained as clearance 3 mm, 93% penetration to the height of sample and trigger force of 8 gram force (gf). Different parameters like hardness (N) during first (hardness 1) and second cycle (hardness 2), springiness (mm), cohesiveness (visco-elasticity), gumminess (hardness x cohesiveness, N), chewiness (gumminess x springiness, Nmm) were calculated from the graph as depicted by Bourne (1978).

Organoleptic evaluation

Sensory evaluation of the samples were carried out by 14 trained panelists on a 9 point hedonic scale (9- like extremely, 1- dislike extremely) as per Murray *et al*. (2001) to establish the overall acceptability (OAA).

Statistical analysis

Statistical analysis was carried out using MS Excel and CoPlot-2003 (Costat Version 6.204, CoHort Software 798, CA, USA). ANOVA for physico-chemical analysis, sensory analysis, TPA and color estimation were carried out and compared using Duncan's multiple range test. Significance testing of the different parameters was determined at $p < 0.05$.

Results and Discussion

Physico-chemical parameters

Physico-chemical properties of DFF and grilled *shami kebab* is shown in Table 2, which indicated that percent cooking yield was better in grilled as compared to DFF method of cooking. It was found that variation in cooking yield do not differ significantly ($p < 0.05$) at 120°C DFF and 180°C. Cooking yield is used in meat industry to predict the behavior of their product during processing (Ulu, 2006). Moisture content variation in *kebab* samples was not significant except in 140°C grilled conditions. Non-significant and slight differences were also observed with other proximate constituents. Protein content was not affected by processing conditions; however pH was obtained significantly different in all processing conditions. Mustfa and Mediros (1985) found significant difference in proximate composition while using three different cooking methods for catfish fillets. It was also observed that

Table 2. Physico-chemical properties of DFF and grilled *shami kebab*

Parameters	Samples			
	DFF		Grilled	
	120 °C	170 °C	140 °C	180 °C
Moisture in *kebab* %	53.15 ± 0.16^{b}	51.88 ± 1.06^{b}	54.67 ± 0.82^{a}	52.49 ± 0.76^{b}
Total ether extract %	8.27 ± 0.24^{a}	7.63 ± 1.21^{ab}	7.02 ± 0.65^{ab}	6.68 ± 0.71^{b}
Protein %	23.95 ± 0.38^{a}	24.83 ± 0.73^{a}	23.42 ± 0.18^{a}	24.37 ± 1.18^{a}
Carbohydrate %	13.88 ± 0.06^{d}	14.79 ± 0.13^{b}	14.05 ± 0.08^{c}	15.69 ± 0.03^{a}
pH at 29±1 ^{0}C	5.62 ± 0.01^{a}	5.51 ± 0.03^{b}	5.33 ± 0.02^{d}	5.43 ± 0.07^{c}
% Cooking yield	91.23 ± 1.14^{b}	88.03 ± 0.81^{c}	93.05 ± 0.53^{a}	90.17 ± 0.25^{b}
% Moisture retention	48.49 ± 0.53^{b}	45.59 ± 1.02^{d}	50.87 ± 0.17^{a}	47.33 ± 0.22^{c}
a_w at 25 °C	0.936 ± 0.01^{b}	0.923 ± 0.02^{c}	0.942 ± 0.02^{a}	0.934 ± 0.02^{b}
Density, ρ (g/cc)	1.432 ± 0.03^{bc}	1.421 ± 0.02^{c}	1.448 ± 0.06^{a}	1.435 ± 0.11^{b}

Mean ± SD (n = 3) with different superscript in same row differ significantly ($p < 0.05$).

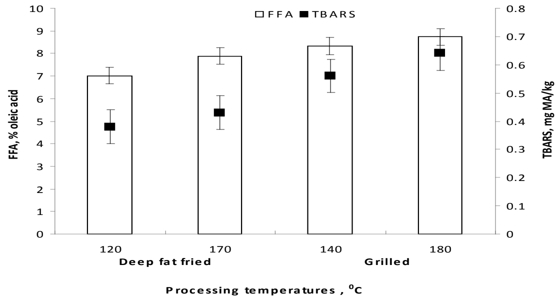

Figure 1. Lipid oxidation pattern of DFF and grilled *shami kebab*

grilled sample's moisture content was more compared to DFF (Broncano *et al.*, 2009). Moisture retention in DFF conditions was obtained less compared to grilled conditions and found significantly different. Water activity was found correspondingly lesser in high temperature processed samples because of efficient moisture removal. Density of the product was also differing with same trend as a_w. Pawar *et al*. (2000) also found that different quality parameters changes with different method of cooking. Though physical properties are measured instrumentally, however they were tested by sensory panel to make it more descriptive for quantitative analysis (Huidobro *et al*., 2005).

Free fatty acid and thiobarbutirtric acid values

Lipid oxidation is one of the important factors that determine the quality and acceptability of meat products (Kranner, 1994). Figure 1 indicates the values of FFA and TBA reactive substances of *shami kebab* subjected for different processing conditions with standard error of mean bars. FFA values ranged from 7.02 to 8.74% oleic acid while TBA values ranged from0.38 to 0.68 mg malonaldehyde/kg. It was observed that FFA values were slightly higher in grilled as compared to DFF conditions and revealed a direct correlation between degree of lipid breakdown and processing temperature. Weber *et al.* (2008) also found that FFA content of catfish fillet was significantly reduced by different cooking methods. Similar trend was observed in TBARS values also. Standard error of mean was found more in TBARS values compared to FFA values. Pikul *et al.* (2000)

also noticed TBA values less in DFF compared to roasted sample. Relationship could be established with sensory characteristics and TBARS values (Nassu *et al.*, 2003). Shin *et al.* (1993) found that temperature of cooking had no significant effects (P > 0.05) on TBA values of either pork or beef samples.

Hunter color values

Color is the main factor affecting meat product acceptability at the time of consumer purchase (Faustman and Cassens, 1989). The color of cooked meat products arise mainly from pigmentation of the meat from which they are made and the ingredients used in the processing (Serdaroglu, 2006). Data of color of DFF and grilled *shami kebab* are depicted in Table 3. The *kebab*s fried and grilled at lower temperature conditions found lighter than the high temperature processed ones and L^* values observed in this case were 43.88, 45.56, 40.13 and 42.35 respectively. L^* values reveal the degree of surface coloration in *kebab*s and their direct relation with temperature. L^* values in all temperature conditions varied significantly ($p < 0.05$) though grilled temperature conditions were found less compared to DFF. At 140°C grilled condition L^* and b^* was obtained highest as 45.56 and 24.52 with lowest a^* as 9.11. Redness (a^*) in product did not differ significantly ($p < 0.05$) at 120°C DFF and 180°C grilled conditions. Yellowness (b^*) in product differ significantly at all processing conditions.

Textural profile analysis

Textural properties play a significant role in the perception and acceptability of any processed food product. Processing conditions and ingredient formulations have a direct impact on the textural behavior of food products. Factors responsible for textural properties in meat products are the degree of extraction of myofibrillar protein, stromal protein, degree of comminuting and level of non meat ingredients (Serdaroglu *et al.*, 2005). Herrero *et al.* (2008) studied TPA of cooked meat sausages and found greater dispersion of textural properties between the samples. Among all textural properties hardness is the most important parameter as it decides the commercial value of meat product (Chambers and Bowers, 1993). Hardness of DFF *kebab*s found lower to the grilled *kebab*s showing a direct correlation with the fat content. Studies conducted by Ulu (2004) and Huang *et al.* (2005) observed low hardness values in meat balls with higher fat content. Trend also showed a significant ($p < 0.05$) difference in the first bite hardness (hardness 1) in *kebab*s processed at higher temperatures than the lower temperature processed ones with in DFF and grilled samples. Higher the temperature of processing harder the product obtained (Lin *et al.*, 2000). Studies also revealed a significant difference ($p < 0.05$) in hardness1 and hardness2 in all the four samples (Table 5) showing a direct impact of temperature and processing conditions. Springiness and cohesive behavior are the markers reflecting the visco-elastic properties of food products. Springiness behavior of grilled *shami kebab* was more compared to DFF in both temperature conditions and varied significantly ($p < 0.05$) with in the processing techniques and it could be correlated with the influence of moisture in the product (Hsu and Yu, 1999). Deep fat frying has induced more moisture loss in the product affecting the visco-elastic behavior and the effect was evident in the springiness and cohesiveness values in the samples under both processing conditions. Chewiness is a derived property from the mathematical product of hardness, cohesiveness and springiness (measured parameters) and it implicates the length of time required (total work done) to chew a food specimen at a constant rate in order to reduce its consistency so that it may be swallowed (Szczesniak *et al.*, 1963; Munoz, 1986). Chewiness of *kebab*s at higher processing temperature conditions was more in both the processing techniques and all the values were significantly different ($p < 0.05$) in all the four *kebab* samples. Instrumental results found correlating with subjective results during the organoleptic evaluation, as the panelists remarked longer chewing time taken for the grilled samples. TPA test parameters represent more than a single sensory attribute and significant correlations were found between sensory chewiness and instrumental hardness ($r = 0.42$, $p < 0.05$), cohesiveness ($r = -0.53$, $p < 0.05$) and springiness ($r = -0.54$, $p < 0.05$) (Montejano *et al.*, 1985). Gumminess is the product of hardness and cohesiveness and it simulates the energy required to disintegrate a semi-solid food before swallowing. Gumminess behavior of all the *kebab* samples revealed a more energy requirement in complete disintegration and retained

Table 3. Hunter color values of DFF and grilled *shami kebab*

Samples		Hunter color values		
		L^*	a^*	b^*
DFF	120°C	43.88 ± 0.12^b	10.73 ± 0.21^b	21.47 ± 0.09^c
	170°C	40.13 ± 0.15^d	13.25 ± 0.23^a	20.14 ± 0.07^d
Grilled	140°C	45.56 ± 0.10^a	9.11 ± 0.54^c	24.52 ± 0.15^a
	180°C	42.35 ± 0.25^c	11.23 ± 0.43^b	22.86 ± 0.27^b

Mean ± SD (n = 3) with different superscript in same column differ significantly (p < 0.05).

Table 4. Sensory scores of shami kebab

Sample		Color	Texture	Aroma	Taste	OAA
DFF	120°C	7.34 ± 0.17^b	7.21 ± 0.38^b	7.21 ± 0.19^b	7.24 ± 0.25^b	7.15 ± 0.20^b
	170°C	7.92 ± 0.38^a	7.90 ± 0.36^a	7.752 ± 0.37^a	7.78 ± 0.40^a	8.01 ± 0.38^a
Grilled	140°C	7.41 ± 0.46^b	6.87 ± 0.45^b	7.08 ± 0.33^b	7.08 ± 0.35^b	7.01 ± 0.19^b
	180°C	7.27 ± 0.38^b	7.31 ± 0.37^b	$7.07 \pm 0.0.14^b$	7.08 ± 0.36^b	7.12 ± 0.13^b

Mean ± SD (n = 14) with different superscript in same column differ significantly (p < 0.05).

Table 5. Texture profile of DFF and grilled *shami kebab*

Texture Parameter	DFF		Grilled	
	120°C	170°C	140°C	180°C
Hardnesss1 (N)	0.971±0.002[d]	1.512±0.016[b]	1.126±0.003[c]	1.635±0.003[a]
Hardness2 (N)	0.513±0.009[d]	1.079±0.014[a]	0.704±0.008[b]	0.765±0.008[c]
Springiness (mm)	18.542±0.478[ab]	17.880±0.020[c]	18.843±0.022[a]	18.113±0.008[bc]
Cohesiveness	0.112±0.004[d]	0.182±0.003[b]	0.170±0.002[c]	0.212±0.009[a]
Chewiness (Nmm)	2.002±0.099[c]	4.935±0.065[a]	3.599±0.062[d]	6.285±0.242[b]
Gumminess (N)	0.108±0.001[c]	0.276±0.013[a]	0.191±0.003[d]	0.347±0.013[b]

Mean ± SD (n = 3) with different superscript in same row differ significantly ($p < 0.05$).

a significant difference ($p < 0.05$) in both processing techniques at all temperature conditions.

Sensory properties

Sensory evaluation results of *shami kebab* in different frying conditions are given in Table 4. These properties are very important for the acceptance of any food product. It was found that color, texture, aroma, taste and OAA of the product were significantly different ($p < 0.05$) at 170°C DFF conditions than other processing conditions applied. Hsu and Chung (1998) and Hsu and Yu (1999) also found that processing conditions and the meat ball formulation have significant effect on product quality. DFF meat products were rated better comparative to grilled one because of their crispy texture and brighter color (Hsu and Yu, 1999; Hsu and Chung, 1998). Overall acceptability indicated that all the panelists rated samples of all processing conditions as good however best product was rated with highest OAA of 8.01 at 170°C DFF processing conditions.

Conclusion

Processing conditions viz. method of processing and temperature have a great impact on the overall quality of *shami kebab*. It was found that temperature of the oil, duration of frying and *kebab* surface (coating) greatly affect the final texture, flavour, and quality attributes. TPA parameters like hardness, cohesiveness, chewiness, gumminess and springiness of DFF *kebab*s found lower to that of grilled *kebab*s. OAA of *shami kebab* was good in all processing conditions with sensory scores more than seven however DFF product fried at 170°C was found better. Most of the physico-chemical attributes of the product showed a direct realtion with method of processing and processing temperature. It was revealed that oxidative and hydrolytic rancidity were lesser in DFF compared to grilled samples. Overall primary consumer acceptance attributes favoured DFF sample fried at 170°C for 2 min, thus it was found better over all the other three samples.

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