



Effect of vacuum tumbling on quality and economy of tandoori chicken prepared from commercial broiler chicken meat

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ABSTRACT

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The present study was aimed to assess the quality and economy of tandoori chicken prepared from commercial broiler chicken meat by marinating the chicken breast meat at different vacuum tumbling time exposures, giving rise to five treatments viz. T₀ (Control-No tumbling), T₁ (30 minutes), T₂ (1 hour), T₃ (2 hours) and T₄ (3 hours). After marination, the samples were immediately cooked for an average of 15 minutes at 250°C to prepare tandoori chicken breast meat. The results revealed a significantly higher pH of product in treatment T₃. No effect of vacuum tumbling was observed on Thio-barbituric acid (TBA) value, tyrosine value (TV), total plate count (TPC), yeast & mould count (YMC). However, significant increase of pH, TBA value and TV with significant decrease in TPC of product was observed as a result of high temperature cooking. Significantly higher sensory scores and profit per Kg were observed in treatment T₃ and lowest in T₀ (Control) with progressive increase from T₀ to T₃. Thus, marination at 2 hours vacuum tumbling followed by 15 minutes cooking at 250°C was found to be ideal for the production of tandoori chicken with better quality and economy.

Keywords: Tumbling, Tandoori, Microbial and Chemical property, Sensory quality, Economy

INTRODUCTION

Since the world is witnessing the rising demand of fast foods, the need of simple and low cost further-processed meat products like chicken tandoori with improved nutritive values will boost the further processing of chicken meat. Various commercial marinade solutions are available in market, containing a complex solution of water, salts, polyphosphate, flavorings and other ingredients, which can be applied to the meat by the techniques of soaking, blending, tumbling or injection. Marination is a popular technique used to accelerate marinade transport throughout the meat, tenderize and improve the quality characteristics of meat products (Pietrasik and Shand, 2003). The marination coupled with tumbling under vacuum is a unique means of tenderization by loosening the muscle structures, disrupting muscle cells and destroying the connection between the myofibers and the connective tissue. Tumbling can be defined as the massaging of meat surfaces and this process involves a transfer of kinetic energy and consequently causes alteration in muscle tissue. Tumbling results in the formation of protein exudate which acts as a sealer when the protein is denatured during thermal processing (Rust and Olson, 1973). This sealer helps to hold in juices during smoking and cooking, and results

in increased yields, increased juiciness and improved slicing characteristics of the finished product. Tumbling also improves the tenderness and causes more uniform cured meat color.

Tandoori Chicken is an Indian dish made by baking large pieces of chicken which have been marinated in spices and yogurt. It is traditionally made on skewers in a tandoor (Indian clay oven). Skinless meat is marinated in a tumbler (massager), operated in a static, vacuum or high pressure to improve marinade absorption and uniformity (Sams, 2001). Operating under vacuum helps in removing the air bubbles from the exudates and might also assists in protein extraction (Barbut, 2005). Cooking temperature has effect with improvement in functional properties of meat and reducing microbial population in product (Giri *et al.*, 2016). Microbiological analysis provided useful information to meat processors regarding the sanitary conditions, microbial spoilage problems and an estimate of expected storage life of meat (Forrest *et al.*, 1975). Total plate count would give as much information as any other suggested microbial index for assessing processed and storage of food products (Ingram, 1961). Meat spoilage did not occur until the total bacterial count reaches level of 10⁶⁻⁸ g⁻¹ or cm⁻² (Gill, 1983). The objective of this work was, therefore, to determine which time period of tumbling is most

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suitable to prepare tandoori chicken. Thus this study was conducted to investigate the effects of various tumbling time periods under vacuum on the chemical and microbial properties, sensory quality and economy of tandoori chicken production.

MATERIALS AND METHODS

Experimental design

For the present study, breast meat obtained from commercial broiler chicken of same hatch and age of 6 weeks, was used. The breast, cut into two equal halves longitudinally, was subjected to marination at different vacuum tumbling time exposures as follows.

- i) T_0 (Control group): No tumbling
- ii) T_1 : 30 minutes tumbling
- iii) T_2 : 1 hour tumbling
- iv) T_3 : 2 hour tumbling
- v) T_4 : 3 hour tumbling

For each treatment, breast from a single bird was used. The composition of the marinade solution was optimized in preliminary investigations and designed as given in Table 1 (g/kg meat). The breast cuts were weighed and placed in a vacuum tumbler (ESK-125, Kakona GmbH Company, Kempten, Germany) together with the corresponding volume of marinade for tumbling marination treatments, whereas, in T_0 group, breast pieces were left in marinade solution for three hours. After marination, the samples were immediately patted with tissue paper to absorb surface water and were hung in the earthen tandoori oven with the use of skewers and cooked for 10-20 minutes at 250°C to prepare tandoori chicken breast. The whole design was replicated twelve times. Fresh meat as well as tandoori prepared thereof were subjected to chemical and microbial analysis as detailed below.

Table 1: Ingredients of Marinade solution (Narasimha Rao et al., 1996)

Ingredients	Quantity (g/Kg of dressed chicken)*
Anise	5
Black pepper	5
Caraway	3
Cardamom	3
Clove	2
Cumin	5
Red chili powder	10
Turmeric powder	5
Salt	35
Kachri	1
Peeled Onion	50
Peeled garlic	20
Curd	500
Lemon	Juice from two lemon fruits (10 ml)
Cinnamon	2
Peeled ginger	20

*Excluding of giblets

pH: The pH measurement was done by digital pH meter (Cyber scan pH 510, Merck). About 5 g of sample was homogenized with 45 ml of distilled water in a laboratory blender for about one minute. The pH was recorded by immersing the combined glass electrodes of digital pH meter in the homogenate. The pH meter was calibrated with standard buffer solutions of pH 4 and 10 as per the user manual instructions, prior to measurement.

Tyrosine value: Tyrosine value was determined by the modified method of Strange et al. (1977). The extract of 20 g sample, prepared in 50 ml of cold 20% TCA by blending for 2 minutes, was used for the estimation of tyrosine value. With reference to the standard graph, the tyrosine value was calculated as mg of tyrosine/g of tandoori chicken sample.

Thio-Barbituric acid (TBA) value: TBA value was estimated as per the Strange et al. (1977). The extract of 20 g sample, prepared in 50 ml of cold 20% TCA by blending for 2 minutes, was used for the estimation of TBA value. The O.D value was taken at 532 nm with the Spectrophotometer (UV- VIS Spectrophotometer, ELICO, SL 164 double beam) and TBA number was calculated as mg malonaldehyde (MDA) per Kg of the sample by multiplying O.D value with K-factor of 5.2.

Total Viable Count (TVC): The microbial load of the samples were estimated as Total Viable Count, following the method described by Swanson et al. (1992) for sampling and making tenfold serial dilution, plating in plate count agar followed by incubation and counting. About 5 g sample was homogenized with 0.1% peptone water (Himedia) with the aid of sterile pestle and mortar under aseptic condition to give a 10^{-1} initial dilution. The homogenate was used for the preparation of serial dilutions up to 10^{-6} with 0.1% peptone water in sterile test tubes. One ml aliquot of each dilution was placed in identified sterile petridishes aseptically. About 12-15 ml of sterile molten and cooled (45°C) plate count agar (Himedia) was poured on each petridish and mixed gently. After setting, the plates were incubated at 37°C for 48 hours and colonies were counted using a Quebec colony counter, which had 25 to 250 colonies per plate. The count was multiplied by the respective dilution and calculated per gram of sample in log values.

Yeast and Mould count: Sabouraud's dextrose agar was used for isolation and enumeration of yeast and mould count. The plates were incubated at 30°C for 48 hours. Colonies were counted and expressed as log CFU/g of sample.

Sensory evaluation: The eating quality parameters like appearance, flavour, juiciness, tenderness and overall acceptability were judged by five semi-trained panelists. The samples were coded so as to mask the identity of the samples. Care was taken to provide uniform sized ready-to-eat tandoori on white porcelain plates for judging. Each panel member was provided with a sensory

evaluation score card to mark their observations and preferences in the appropriate box provided against each attribute of a particular sample.

Statistical analysis

All the data were analyzed by one-way analysis of variance using general linear model (GLM) procedure of the SPSS software-20. The Duncan’s New Multiple Range Test was used to detect significant differences between individual means of respective treatments with significance level set at (p<0.05).

RESULTS AND DISCUSSION

Chemical properties

The results pertaining to chemical properties (pH, TBA value and Tyrosine value) of fresh meat and tandoori product has been presented in Table 2.

pH: There was no significant difference in pH of fresh meat samples before the application of treatments. However, significant (P<0.05) rise in pH of tandoori product produced thereof was observed. The significant differences were also observed between the treatments in the tandoori product. The significantly higher pH value was observed in treatment T₃ (2 hours tumbling) and lowest in T₀ (Control-No tumbling), whereas, T₁, T₂ & T₄ yielded intermediate values. It can be observed from the results that cooking of meat to tandoori has resulted in significant rise of pH and among the tandoori products tumbling has significantly increased the pH of the product.

It has been reported that cooked meat has a slightly higher pH than the raw meat because during cooking, the acidic groups of the meat proteins are expelled with the juices and the remaining meat proteins become more alkaline (Law et al., 1967). Higher degree of free acidic group from the meat protein subjected to heat can be a reason for rise in pH of cooked meat than raw meat (Lawrie, 1998). Increase in pH can also be ascribed to increase in free imidazolium groups of histamine in the myofibrillar proteins. The increase of pH as a result of tumbling may be due to the increased penetration of curing solution into the meat samples (Froning and Sackett, 1985).

Thio-Barbituric Acid (TBA) value: The oxidation of muscle and product is of primary concern among food technologists as it is considered as a major cause of

deterioration in the quality of muscle foods. MDA (Malonaldehyde), a secondary product from lipid oxidation, is commonly used as an oxidation index in muscle foods, and different analytical techniques have been reported to determine and quantify it. There were no significant differences in TBA values of fresh meat samples prior to the application of treatments. However, significantly (P<0.05) higher TBA values of tandoori product produced thereof were observed. However, no significant differences were observed between the treatments in the TBA values of tandoori product. These observations clearly revealed that high temperature cooking increased the TBA value of the meat product produced and no effect of tumbling was observed.

TBA was used as an indicator of food quality and was highly correlated with rancidity and warmed over flavour in muscle foods (Wilson et al., 1976). Younathan and Watts (1959) stated that heating doubles the amount of free fatty acids in meat which might be due to irreversible conversion of iron in the porphyrin ring of myoglobin pigments to the ferric form during heating. It is only ferric form of iron which catalyzes the lipid oxidation, not the iron bound to transferrin or ferritin or the central iron component in heme pigments (Ahn et al., 1993). In the present study, cooking might have enhanced phospholipids oxidation, thus causing TBA values to rise (Gokalp et al., 1983). Storage time increases TBARS values followed a significant (p<0.05) linear increasing trend. (Para et al., 2017)

Tyrosine Value: The Tyrosine values of fresh meat samples used for various treatments were statistically similar to each other. However, the tandoori product produced thereof has shown significantly (P<0.05) higher tyrosine values as compared to fresh meat samples. No significant differences were observed in the tyrosine values of the product from different treatments. From these results, it can be stated that high temperature cooking increases the Tyrosine value of the meat product produced with no effect of tumbling. Increase in the concentration of tyrosine, ammonia and NPN compounds occur due to microbial proteolytic activity, which occurs only when spoilage is in a very advanced stage because bacteria usually produced proteolytic enzyme in the late phase of

Table 2: Chemical properties of fresh meat and the tandoori product produced thereof

Treatment groups	Parameters					
	pH		TBA value (mg MDA/kg)		Tyrosine value	
	Fresh meat	Product	Fresh meat	Product	Fresh meat	Product
T ₀	5.57±0.08	5.67±0.04 ^a	0.16±0.01	0.36±0.03 ^b	1.06±0.09	2.96±0.86 ^b
T ₁	5.60±0.04	5.77±0.06 ^b	0.18±0.01	0.40±0.04 ^b	1.26±0.05	2.59 ±1.04 ^b
T ₂	5.58±0.04	5.79±0.03 ^c	0.19±0.01	0.43±0.05 ^b	1.13±0.04	2.59±1.36 ^b
T ₃	5.65±0.05	5.90±0.05 ^c	0.18±0.01	0.40±0.04 ^b	1.23±0.09	2.69±1.18 ^b
T ₄	5.69±0.19	5.81±0.06 ^b	0.16±0.01	0.37±0.03 ^b	0.93±0.01	2.46±0.87 ^b
F Value	0.55	2.35	0.26*	0.55*	0.08*	1.45*

Column bearing different superscripts (ABC) differ significantly and rows bearing different superscripts (ab) differ significantly. NS- Not significant (P>0.05)

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growth (Dainity et al., 1975). However, in the present study, this cannot be the reason as the cooking was done at a very high temperature. Thus, the thermal processing at high temperature might have caused an increase in the rate of protein break down resulting more free amino acids which in turn lead to higher tyrosine values in the product (Devadason et al., 2014).

Microbial properties

The results pertaining to microbial properties of fresh meat and tandoori product has been presented in Table 3.

Table 3: Microbial properties of fresh meat and the tandoori product produced thereof

Parameters	Total Plate Count (TPC)		Yeast Mould Count (YMC)	
	Fresh meat	Product	Fresh meat	Product
T0	4.30±0.018	3.49±0.01	3.44± 0.01	3.39± 0.01
T1	4.31± 0.013	3.50±0.01	3.47±0.01	3.43± 0.01
T2	4.29±0.016	3.48±0.01	3.46±0.01	3.37±0.01
T3	4.31± 0.012	3.48±0.01	3.46±0.01	3.41±0.01
T4	4.32±0.014	3.49±0.01	3.45±0.01	3.40±0.01
F Value	0.37*	0.98*	1.46	1.46

Rows bearing different superscripts (ab) differ significantly. NS-Not significant (P>0.05)

Total Plate Count (TPC): The Total Plate Count (TPC) of fresh meat samples revealed no significant differences before the application of various treatments. However, the tandoori product produced thereof has shown significantly (P<0.05) lower TPC as compared to fresh meat samples. No significant differences were observed in the TPC of the product as a result of different treatments. It was observed that due to high temperature cooking, the decline of microbial count in tandoori product occurred without any effect on tumbling. It was reported that internal temperature of 80°C attained during preparation of tandoori chicken is sufficient to destroy *Coliforms* and *S. aureus* like organisms (Nair et al., 1995). However, in contrast, Ghavimi et al. (1986) reported that tumbling would enhance water and acid transport between meat and solution; and marinade penetration and diffusion were therefore accelerated, thus decreasing the microbial count.

Yeast and Mould Count: The yeast and mould count of fresh meat before application of different treatments and that of tandoori product revealed no significant difference

between different treatments. Similar to the present study, Bharti et al. (2011) reported no significant effect of tumbling time on the yeast and mould count of chicken tikka. However, the erratic result of non-significant difference in YMC between fresh meat and cooked product remained unexplained.

Sensory evaluation: The sensory evaluation of tandoori chicken product revealed significant differences between the treatments (Table 4).

The appearance, flavor, texture and juiciness scores were significantly higher in treatment T₃ as compared to T₀, T₁ and T₂; whereas, no significant differences were observed between T3 and T4. The overall acceptability score was significantly higher in treatment T₃ as compared to other treatments. There was no significant difference between T₂ and T₄. These observations indicate that two hours tumbling recorded highest sensory evaluation score as compared to other treatments. This improvement in sensory scores might be due to increased penetration of marinade solution in the tumbled product. The results of the present study are supported by the similar findings of Theno et al. (1978), Bharti et al. (2011), Harmon et al. (1992) and Acton (1972).

Economics of tandoori chicken preparation

The economics of cost of production of 1 kg tandoori of broiler meat using meat, curd, spices and condiments were given in Table 5. From the table, it is vividly clear that the profit per kg tandoori progressively increases with increase in tumbling time up to 2 hours only. The highest profit of Rs 99.5/Kg of meat was observed at 2 hour of vacuum tumbling and lowest in treatment without tumbling. The profit increases as a result of increasing processing yield. The processing yield increases with tumbling time as it increases the marinade uptake (Froning and Sackett, 1985). The product tumbled for a longer time has a lower cooking loss as compared to those cooked for a short time due to increased amount of extractable soluble proteins (Dzudie and Okubanjo, 1999; Muller, 1991; Ghavimi et al., 1986).

The current study concludes that high temperature cooking has significantly increased pH, TBA value and Tyrosine value, whereas, significantly highest pH in tandoori is observed as a result of 2 hours of vacuum tumbling. No effect of vacuum tumbling is observed on microbial quality of the tandoori, whereas, high temperature cooking significantly reduces microbial load

Table 4: Sensory Evaluation score of tandoori chicken product

Parameters	Appearance	Flavor	Texture	Juiciness	Overall acceptability
T0	6.70±0.09 ^A	6.38±0.09 ^A	6.39±0.09 ^A	6.40±0.10 ^A	6.51± 0.09 ^A
T1	7.39±0.07 ^B	7.14±0.08 ^B	7.17±0.07 ^B	7.17±0.08 ^B	7.08±0.07 ^B
T2	7.72±0.07 ^C	7.67±0.06 ^C	7.64±0.07 ^C	7.63± 0.07 ^C	7.68±0.07 ^C
T3	7.93±0.05 ^D	7.82±0.06 ^C	8.01±0.06 ^D	8.02±0.06 ^D	8.04±0.06 ^D
T4	7.78±0.08 ^{CD}	7.82±0.09 ^C	7.92±0.09 ^D	7.96± 0.08 ^D	7.77± 0.09 ^C
F Value	46.89**	62.70**	73.72**	70.70**	66.70**

Column bearing different superscripts (ABC) differ significantly. NS-Not significant (P>0.05)

Table 5: Economics of tandoori chicken production

Treatment	Meat cost/Kg	Processing cost/Kg	Marinade cost/Kg	Total expenditure/Kg	Cost/Kg tandoori	Processing yield (%)	Total income/Kg	Profit/Kg
T0	120	0	37	157	350	50	175.0	18.0
T1	120	2	37	159	350	60	210.0	51.0
T2	120	4	37	161	350	70	245.0	84.0
T3	120	6	37	163	350	75	262.5	99.5
T4	120	10	37	167	350	72	252.0	85.0

in the product produced. The 2 hours vacuum tumbling results in significantly higher sensory evaluation scores along with the highest per Kg profit of the tandoori product.

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