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Full Length Research Paper

Effect of vacuum tumbling time on physico-chemical, microbiological and sensory properties of chicken tikka

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Chicken tikka prepared by using vacuum tumbler (tumbling time 15, 30 and 45 mins) were stored at refrigerated temperature (4±1°C) and subjected to comparative studies on 0, 7 and 14 day. Product having more tumbling time showed significant (P<0.05) higher values for cooking yield, pH, moisture and ash%, lower values for cholesterol (mg/100 g), and protein%. The thio-barbituric acid (TBA) value (mg malonaldehyde/kg) showed a non-significant (P>0.05) higher value with control, however, a significant increasing trend was noticed throughout the storage period. Microbiological study revealed that the microbial count (cfu/g) in total plate count and lipolytic count were significantly lower (P<0.05) in product having more tumbling time and in all groups of chicken tikka, the microbial count increased significantly with advancement of storage period. All the sensory attributes viz. appearance and color, texture, juiciness and overall acceptability increased significantly with increase in tumbling time.

Key words: Vacuum tumbling, chicken tikka, sensory property, meat processing.

INTRODUCTION

Chicken tikka is a Pakistani dish made by baking small pieces of chicken which have been marinated in spices and yogurt. It is traditionally made on skewers in a tandoor (Indian clay oven) and is usually boneless. Marination is used to improve both sensory (flavor, color moisture and texture) as well as functional properties of meat (water-holding capacity, stability and cooked yield). Marinades are preliminary a mixture of salt, organic acids, nitrites and spices in a solution in which meat is soaked. Skinless and boneless meat are marinated in a tumbler (massager), operated in a static, vacuum or high pressure to improve marinade absorption and uniformity (Sams, 2001). The agitation, which can be applied for one to several hours (slow or intermittent), helps disrupt some of the tissue structure, assists in distributing the brine solution and develops a protein exudate that will later serve as “glue” to bind the meat chunks during cooking. Operating under vacuum helps in removing the air bubbles from the exudate and might also assists in protein extraction (Barbut, 2005). The results of tumbling meat have been studied by several investigators. According to Treharne (1971), tumbling is defined as the massaging of meat surfaces; however, many meat processors now make a distinction between “Tumbling” and “Massaging”. Tumbling involves the physical process of meat rotating in drum, falling and making contact with metal walls and paddles. This process involves a transfer of kinetic energy and consequently causes alteration in muscle tissue.

In contrast, the process of “Massaging” is considerably less rigorous. It usually involves a stationary drum with paddles rotating around a vertical axle. This process does not involve free falling of meat contents. Consequently, the process mainly involves muscle tissue rubbing other muscle tissue and the smooth surface of the drum. Theoretically, this result is less transfer of kinetic energy and therefore less heat rise in the product. Tumbling has many beneficial effects, some of which are due to the formation of a protein exudate. According to

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Table 1. Composition of spice and condiment mix.

Ingredient	%
Garlic paste	10.8
Ginger paste	2.7
Onion paste	27.0
Red chilly powder	2.1
Coriander powder	4.0
Garam masala powder	2.7
Curd	40.9
Lime	5.4
Salt	4.0
Sodium nitrite	150 ppm
STPP(Sodium tri-poly phosphate)	0.4

Rust and Olson (1973), this protein exudate acts as a sealer when the protein is denatured during thermal processing. Vartorella (1975) and Krause (1976) added that this sealer helps hold in juices during smoking and cooking, and results in increased yields, increased juiciness, and improved slicing characteristics of the finished product. Other benefits of tumbling include improved tenderness and more uniform cured meat color (Krause, 1976).

To provide ready to cook, value added products of poultry and seafood, at either the food processing plant or the supermarket/butcher shop vacuum tumbling is an important method. The vacuum causes the product to absorb more marinade, which makes the product juicier and faster cooking.

The tumbling massages the product, which makes it tenderer. With all of the aforementioned physical changes caused by tumbling or massaging, it seems logical that there must be several significant changes that occur due to alteration in tumbling time. In view of the above facts the present study was envisaged with the following objectives:

1. Determination of influence of vacuum tumbling time on eating quality characteristics of prepared chicken tikka and selecting the best on the basis of physico-chemical, microbiological and sensory evaluation;
2. Assessment of physico-chemical, microbiological and sensory properties of chicken tikka during storage.

MATERIALS AND METHODS

The experiment was conducted in the Department of Livestock Products Technology, College of Veterinary and Animal Sciences, G.B. Pant University of Agriculture and Technology, Pantnagar. Poultry of nearly 1.5 kg body weight were procured from instructional poultry farm (IPF) Nagla, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. A total of 14 birds were utilized for the study. Birds used in this study were randomly selected from their respective flocks at IPF, Nagla. The birds were slaughtered at the Department of Livestock Products Technology following standard protocol and allowed to bleed for 180 s, in bleeding cones.

The birds were dressed as per approved scientific methods and manually de-boned. The slaughtering technique and transportation method was approved by the Ethical committee involving concerned Head of the Department and other members. The meat obtained was washed with clean water. Boneless lean meat was collected and stored. On the basis of literature available and various preliminary trials, four groups of chicken tikka were prepared. that is, one control and three treatments (vacuum tumbled for 15, 30 and 45 min respectively). Spice mix, condiment mix, curd, oil, lemon, table salt and packaging materials were procured from local market. All the chemical and media used in the study were of analytical grade and were obtained from standard firms (Hi media, Merck; India).

Preparation of chicken tikka

Boneless lean meat was cut into small cubes of nearly one inch size with the help of deboning knife. Spice and condiment mix was prepared as per the formulation given in Table 1. The paste along with condiment paste and spice mix was properly mixed with finely beated curd. Later chicken pieces were added to the above mix. The prepared mix was weighed equally in four parts and vacuum tumbled in a vacuum tumbler (Promarks Vac- TM50) for 15, 30, 45 min. A control was also prepared along with tumbled treatments.

Tumbled and non tumbled meat was cooked in a preheated oven to maximum 240°C under smokeless, moderate and uniform heat. The temperature was maintained in the oven throughout the cooking period of about 20 min. to permit thorough and uniform cooking. During cooking the meat pieces were turned over once to avoid drying, charring or blistering. Cooking was done till the meat attained a golden brown colour and was fully cooked. The chicken tikka were packed aerobically in adequate number of LDPE bags, sealed in a packaging machine and stored at refrigeration temperature (4±1°C). The samples of chicken tikka were analyzed for physico-chemical, microbiological and sensory characteristics at regular intervals of 0, 7 and 14 days or till spoilage, whichever was earlier.

Analytical procedure

Physico chemical characteristics

Cooking yield: To determine the cooking yield tumbled and non tumbled chicken tikka were weighed before and after cooking. The cooking yield was calculated as:

$$\text{Cooking yield (\%)} = \left[\frac{\text{Weight of cooked chicken tikka}}{\text{Weight of raw chicken tikka}}\right]\times 100$$

pH determination

For determination of pH, representative samples of 10 g of patties from each treatment were homogenized for 30 s with 100 ml distilled water using a blender. The pH of prepared homogenates was recorded by using a digital pH meter (WTW®, Germany, Model 330i fitted with Sen Tix sp electrode) by immersing the electrode of pH meter into aliquot of the sample (Egbert et al., 1992). The pH meter was calibrated with known buffers of pH 7 and 4.01 before use every time.

Cholesterol content

Total cholesterol was determined as per Zaltkis et al. (1953) with little modifications as described by Rajkumar et al. (2004). Lipid extract was prepared by mixing one gram of sample with 10 ml of freshly prepared 2:1 Chloroform: Methanol solution and homogenizing it in a blender. Homogenate was filtered using Whatman filter paper No. 42 and 5 ml of filtrate was added with equal quantity of distilled water, mixed and centrifuged at 3000 rpm for 7 min. Top layer (methanol) was removed by suction. Volume of bottom layer (Chloroform) having cholesterol was recorded. The O.D. of standard and sample against blank was taken at 560 nm. Total cholesterol mg percent was recorded as follows:

$$\frac{\text{O.D.of sample}}{\text{O.D.of standard}} \text{ x } \frac{\text{Vol.of Choloform(ml)}}{\text{Weight of the sample taken (g)}} \text{ x conc.of standard} = \text{Cholesterol in (mg)\%}$$

Proximate analysis

Moisture, fat, protein and total ash contents of cooked patties were determined by the procedure given by AOAC (1984).

Storage study

Thiobarbituric acid (TBA) value

TBA was estimated as per procedure given by Tarladgis et al. (1960).

Microbiological analysis

Total plate count, coliform count, lipolytic count and yeast and mold count were determined as per the procedure described by APHA (1992).

Sensory evaluation

The sensory qualities of samples were evaluated by meat descriptive analysis method. The patties were oil fried and served warm to panelists for sensory evaluation. The sensory quality of samples was evaluated using 8 point descriptive scale (Keeton et al., 1984) where 8 denoted extremely desirable and 1 denoted extremely poor. A sensory panel of seven judges were requested to evaluate the product for different quality attributes viz: appearance, flavor, texture, juiciness and overall acceptability.

Statistical analysis

Statistical analysis of the data obtained, was done using ANOVA technique according to the method described by Snedecor and Cochran (1994) by completely randomized design (CRD). Further, to determine the significance between treatments, Tukey's HSD test was conducted by a SPSS® – 16 software package.

RESULTS AND DISCUSSION

The abbreviations used in results for treatments and control are as follows for control: Con; for vacuum tumbling 15 min: VT15, for vacuum tumbling 30 min: VT30 and for vacuum tumbling 45 min: VT45. Data presented in Table 2 indicate that cooking yield of chicken tikka of group VT45 was significantly (P<0.05) higher than the Con, VT15 and VT30 groups. This result is in agreement with the findings of Dzudie and Okubanjo,(1999) who reported that the product tumbled for a longer time had a lower cooking loss, when compared to those cooked for a short time due to increased amount of extractable soluble proteins. Muller (1991) also reported higher product yield due to tumbling as compared to non-tumbled control. Increased tumbling time provides better chances for migration of curing solution in increased ionic strength and pH, which in turn enhance the product yield. Ghavimi et al. (1986) observed insignificant difference between product yield from vacuum and aerobically tumbled meats. These data agree with the report of Rust and Olson (1973) who felt that the exudates of myofibrillar protein seals moisture in the product as it coagulates on and immediately below the surface.

The pH of group VT45 was observed to be 6.247±0.014, which was found to be highest among all the different test groups (Table 2). The observations are same as those of Froning and Sackett (1985) who reported that pH of the cooked muscle was significantly higher in tumbled carcasses as compared to the non tumbled treatments. It might be due to increased penetration of curing solution in treatment as compared to the control samples. Plimpton et al. (1991) also reported higher pH in tumbled samples. Cassidy et al. (1978) stated that besides enhanced distribution, salt might retard enzyme action necessary for glycolysis and production of lactic acid. More tumbling time causes rapid migration of curing solution in the muscle tissue. Ledward (1979) also found that ham tumbled under vacuum had comparatively higher cure absorption. The increment of pH could be attributed to the modification of meat protein conformation during thermal denaturation (Ang and Hamm, 1982).

The Mean±SE for cholesterol level for VT45 was 40.091±1.382 (mg/100 g) which differs significantly from Con, VT15 and VT30 but later two groups that is VT15 and VT30 did not differ significantly from each other (Tables 2). Cholesterol levels were found to be slightly higher in mechanically deboned broilers as compared to hand-deboned ones (Sharma et al., 2002). Moisture content of group VT45 was significantly (P<0.05) higher than the Con but no significant difference between VT15, VT30 and VT45 groups was seen (Table 3). It might be due to comparatively high levels of salt soluble proteins, which form a seal upon heating, thus retaining higher

Table 2. Effect of different treatments on cooking yield (%), pH, cholesterol (mg/100 g) and TBA values (mg malonaldehyde/kg) of chicken tikka (Mean±SE).

Parameter \ Treatment	Control	Vacuum tumbling 15 min	Vacuum tumbling 30 min	Vacuum tumbling 45 min
Cooking Yield (%)	$65.702^{a} \pm 0.089$	$71.044^{b} \pm 1.007$	$78.862^{c} \pm 0.332$	$80.752^{d} \pm 0.385$
pH	$6.002^{a} \pm 0.020$	$6.115^{b} \pm 0.010$	$6.177^{c} \pm 0.009$	$6.247^{d} \pm 0.014$
Cholesterol (mg/100 g)	$64.915^{a} \pm 1.160$	$55.712^{b} \pm 1.282$	$52.629^{bc} \pm 1.163$	$40.091^{d} \pm 1.382$
TBA (mg malonaldehyde/kg)	0.362 ± 0.004	0.354 ± 0.004	0.350 ± 0.005	0.346 ± 0.004

*Mean values bearing same or no superscript row wise do not differ significantly (P<0.05).

Table 3. Effect of different treatments on proximate composition (%) of chicken tikka (Mean±SE).

Parameter \ Treatment	Control	Vacuum tumbling 15 min	Vacuum tumbling 30 min	Vacuum tumbling 45 min
Moisture (%)	$60.426^{a} \pm 0.241$	$62.256^{b} \pm 0.436$	$62.757^{bc} \pm 0.568$	$63.300^{bcd} \pm 0.455$
Protein (%)	28.435 ± 0.892	$26.820^{a} \pm 0.585$	$26.149^{ab} \pm 0.249$	$25.766^{abc} \pm 0.197$
Fat (%)	10.806 ± 0.016	10.775 ± 0.015	10.759 ± 0.010	10.746 ± 0.017
Ash (%)	0.956 ± 0.012^{a}	0.987 ± 0.018^{a}	1.014 ± 0.008^{ab}	1.045 ± 0.007^{bc}

*Mean values bearing same or no superscript row wise do not differ significantly (P<0.05).

moisture during cooking (Rust and Olson, 1973). Vacuum tumbled meat block had slightly higher moisture than aerobically tumbled product, which could also be accounted for the same reason.

Protein content of group VT45 was significantly (P<0.05) lower than the Con, VT15 and VT30 groups (Table 3). Con. and VT15 groups did not differ significantly but VT30 significantly differed from Con. These results are in agreement with that of (Theno et al., 1978). Retention of higher amount of moisture in the tumbled samples decreased protein percentage. The ether extract of different groups did not exhibited significant difference from each other as shown in Table 3 and it ranged from 10.746 to 10.806%. Similar were the findings of Theno et al. (1978) who reported that there were no significant (P<0.05) differences in the fat percentage of tumbled and control samples. The Mean±SE for ash for VT45 was 1.045±10.007% which differs significantly from Con. VT15 and VT30 groups did not differ significantly but VT30 significantly differed from Con. Babji et al. (1982) reported that tumbling disrupted muscle cells, thus facilitating the diffusion of curing ingredients into the meat. This could explain the higher ash content of the tumbled product. In contrast, Katsaras and Budras (1993) found no significant difference in chemical composition of the tumbled salted and non-tumbled salted turkey breast meat.

There was no significant (P<0.05) difference in the TBA value of the chicken tikka of different test groups. But it was found to be non-significantly lower in VT45 group as compared to Con, VT15 and VT30 groups (Table 2). Total plate count of group VT45 was significantly (P<0.05) lower than Con, VT15 and VT30 groups (Table 4). VT15 and VT30 groups did not differ significantly but VT15 differed significantly from Con. Because the meat surface is destructured by tumbling, the transfer surface area is likely to increase. Consequently, tumbling would enhance water and acid transport between meat and solution. Marinade penetration and diffusion are therefore accelerated, thus decreasing the microbial count (Ghavimi et al., 1986, Pohlman et al., 2002). Ockerman et al. (1978) reported significant decontamination effect by vacuum tumbling by using antimicrobial agents such as trisodium phosphate and cetylpyridium chloride.

The lipolytic count of VT45 group was found to be lowest 2.847±0.001 log cfu/g, as shown in Table 4, and it differs significantly from the lipolytic count of other three groups. Tumbling, which has been shown to help in the distribution of curing agents and marinade solution during processing in several studies (Leak et al., 1984 and Kamchorn et al., 1983) should increase the distribution of antimicrobial agents. In the current study also, at a given storage time and enhanced tumbling time, fewer total microorganisms were detected. The coliform colonies and yeast and mold colonies were not detected on 0 day in all groups that is Con, VT15, VT30 and VT45 group.

Appearance and color score from sensory panel of group VT45 was significantly (P<0.05) higher than the Con, VT15 and VT30 groups (Table 5). Color and appearance of the chicken tikka were improved significantly due to tumbling. Similar finding was also reported by Theno et al. (1978). This might be due to

Table 4. Effect of different treatments on microbiological quality (log cfu/gm) of chicken tikka (Mean±SE).

Parameter \ Treatment	Control	Vacuum tumbling 15 min	Vacuum tumbling 30 min	Vacuum tumbling 45 min
TPC	3.398 [a] ± 0.000	3.383 [b] ± 0.001	3.375 [bc] ± 0.001	3.368 [cd] ± 0.001
Lipolytic	2.943 [a] ± 0.000	2.896 [b] ± 0.000	2.876 [c] ± 0.001	2.847 [d] ± 0.001
Coliforms	ND	ND	ND	ND
Yeast and Molds	ND	ND	ND	ND

*Mean values bearing same or no superscript row wise do not differ significantly (P<0.05).

Table 5. Effect of different treatments on sensory attributes (scores) of chicken tikka (Mean±SE).

Parameter \ Treatment	Control	Vacuum tumbling 15 min	Vacuum tumbling 30 min	Vacuum tumbling 45 min
Appearance/Color	6.408 ± 0.015 [a]	6.531 ± 0.039 [b]	6.656 ± 0.042 [c]	6.777 ± 0.047 [d]
Flavor	6.019 ± 0.108	6.170 ± 0.069	6.270 ± 0.058	6.394 ± 1.102
Texture	6.015 ± 0.027 [a]	6.400 ± 0.061 [b]	6.764 ± 0.006 [c]	7.019 ± 0.011 [d]
Juiciness	5.996 ± 0.038 [a]	6.398 ± 0.032 [b]	6.824 ± 0.027 [c]	7.229 ± 0.019 [d]
Overall acceptability	6.118 ± 0.031 [a]	6.437 ± 0.032 [b]	6.746 ± 0.044 [c]	6.991 ± 0.016 [d]

*Mean values bearing same or no superscript row wise do not differ significantly (P<0.05).

increased penetration of curing solution containing nitrite in the tumbled product. Weiss (1973) reported that vacuum treatment allowed meat system to make more efficient use of nitric oxide formed from nitrite. A significant improvement in internal color development is of particular interest and agrees with the reports of Theno et al., 1976 and Treharne (1971). The effect of tumbling on the rate and uniformity of diffusion of curing ingredients probably accounts for the color development, but the disruption of sarcolemma as suggested by Krause (1978) could increase the accessibility of myoglobin to the nitrite, thus helping to explain the significant improvement in color development. There was no significant (P<0.05) difference observed in the flavor score of chicken tikka due to different treatments. But it was found to be lower in Con as compared to VT45 (Table 5). Harmon et al. (1992) and Acton (1972) reported that tumbling significantly improved flavor scores. However, in this study no significant differences were observed.

The mean value score for texture of chicken tikka differs significantly (P<0.05) from each other. The texture of chicken tikka having tumbling time of 45 min was found to be highest (7.019±0.011), as shown in Table 5, and it differs significantly from the texture of other three groups. Improvement in tenderness in tumbled product might be due to cellular disruption and myofibrillar fragmentation of the muscle tissue (Babji et al., 1982). During tumbling, enhanced extraction of salt soluble proteins and mechanical action of friction allowed protein-to-protein interaction during cooking (Pietrasik and Shand, 2005) resulting in improved textural characteristics. Acton (1972) also observed better texture and improved sliceability due to tumbling. Udayasaha et al. (1999) suggested that the beneficial effect of brine addition could be due to moisture enhancement, which would improve the textural characteristics of the final product.

The juiciness score of group VT45 was observed to be highest and of group Con to be lowest among the entire different test groups (Tables 5). The results confirm the finding of Theno et al. (1978) who reported that juiciness scores of tumbled product were significantly higher than control. It could be due to higher retention of moisture by the extracted salt soluble proteins. However, irrespective of time, juiciness scores of aerobically tumbled and vacuum tumbled products are different and comparable within their comparative groups. The overall mean value of acceptability score was superior for VT45 followed by for VT30, VT15 and Con (Table 5). Tumbling significantly improved the overall acceptability of product.

A similar finding was reported by Theno et al. (1978) who found improved overall acceptability of restructured buffalo meat slices. Vacuum tumbling for 3 h enhanced the overall acceptability of product to a great extent. The results of sensory agree with the statements of Theno et al. (1976), who illustrated that tumbling had a significant influence on external appearance, internal color, sliceability, taste and aroma. The most dramatic effects were in slice ability and yield. Based on the result of physico-chemical, microbiological and sensory analysis, the product VT45 was selected for storage studies along

Table 6. Effect of treatment and control on pH and TBA values (mg malonaldehyde/kg) of chicken tikka during storage.

Storage period	Treatment		
	Control	Vacuum tumbled (VT45)	Day mean
		pH	
0 day	6.022 ± 0.020^{c}	6.152 ± 0.040^{ec}	6.087 ± 0.030
7 day	6.085 ± 0.018^{b}	6.212 ± 0.040^{db}	6.148 ± 0.029
14 day	6.145 ± 0.014^{a}	6.267 ± 0.038^{da}	6.206 ± 0.026
Treatment mean	6.084 ± 0.017	6.210 ± 0.026	
		TBA	
0 day	0.362 ± 0.004^{c}	0.351 ± 0.004^{e}	0.357 ± 0.004
7 day	0.630 ± 0.211^{b}	0.591 ± 0.003^{db}	0.610 ± 0.107
14 day	1.296 ± 0.011^{a}	0.909 ± 0.018^{da}	1.102 ± 0.014
Treatment mean	0.762 ± 0.075	0.617 ± 0.008	

*Mean values bearing same or no superscript row wise do not differ significantly (P<0.05).

with control.

Evaluation of effect of treatment (VT45) and control on storage stability

A significant (P<0.05) effect of treatment as well as storage period on TBA values of chicken tikka during the observation period and the interaction between treatment and storage period was also found to be highly significant (P<0.05). The initial TBA (mg malonaldehyde/kg) value for Con group was found to be 0.362±0.004 and for VT45 it was 0.351±0.004. These values increased significantly (P<0.05) during refrigerated storage reaching 1.296±0.001 for Con and 0.909±0.018 for VT45 on 14th day of observation. The overall mean values of TBA for Con and VT45 groups were significantly (P<0.05) different, which were found to be 0.762±0.075, and 0.617±0.008 respectively (Table 6). With the advancement of storage period there was increase in the TBA values of the treatments, this might be due to the increased lipid oxidation and production of volatile metabolites in the presence of oxygen during storage and aerobic packaging (Kumar and Sharma, 2004).

A significant (P<0.05) effect of treatment as well as storage period on pH values of chicken tikka was observed during the observation period and the interaction between treatment and storage period was not found to be significant (P<0.05) (Table 6). The overall mean value of VT45 group was significantly (P<0.05) higher than the Con group. A significantly (P<0.05) increasing trend was also observed in pH with the advancement of storage period. The overall mean value for the test group was 6.152±0.040 on 0th day and increased to 6.267±0.038 on 14th day of observation (Table 6). Increasing trend observed in pH during storage may be attributed to proteolysis, due to bacterial growth. The breakdown products of proteins contributed to increase in the pH of product. However, Cremer and Chipley (1997) reported an increase in pH during storage of low fat pork patties attributed to proteolysis due to bacterial growth.

A highly significant (P<0.01) increasing trend was also observed in TPC with the advancement of storage period (Table 7). The overall mean value for test group was 3.368±0.001 log cfu/g on 0th day and increased to 5.027±0.005 log cfu/g on 14th day of observation. The products under treatment maintained lower TPC values than the control throughout the storage period and were within the limit as proposed by (Froning et al., 1971) for cooked meat products that is, 5.33 x 10^3 cfu/g for total plate count. Tandon, 1974 also reported that microbial loads in turkey frankfurters showed some increase in total counts during refrigeration storage. Hobbs (1983) reported a bacterial count of 7.8×10^7/g in chicken sausages stored at 5°C for 7 days. The lipolytic count of Con and VT45 group were 2.944±0.001 and 2.846±0.001 log cfu/g respectively on 0th day of storage which increased significantly to 4.007±0.031 log cfu/g in Con and 3.971±0.014 log cfu/g in VT45 group respectively on 14th day of observation (Table 7). A significant (P<0.05) increasing trend was also observed with the advancement of storage period. The overall mean value for the test group increased to 3.971±0.014 log cfu/g on 14th day of observation.

The coliforms were not detected on 0th day in Con and VT45 group On 7th day coliform count were observed in both Con and VT45 group but Con showed a significantly (P<0.05) higher value that is, 1.316±0.001 log cfu/g than the treatment (Table 7). The higher coliform count observed in the processed treatments compared with fresh might be caused by contamination due to either the equipment or the ingredients. Coliforms are common contaminants in fresh and processed foods that are often detected in food processing area (Jay, 1992; Anand et al., 1992). The yeast and mold colonies were not

Table 7. Effect of treatment and control on microbiological quality (log cfu/gm) of chicken tikka during storage.

Storage period	Treatment		
	Control	Vacuum Tumbled (VT45)	Day Mean
Total plate count			
0 day	3.398 ± 0.001^{c}	3.368 ± 0.001^{f}	3.383 ± 0.001
7 day	4.266 ± 0.001^{bc}	4.190 ± 0.023^{e}	4.228 ± 0.008
14 day	5.178 ± 0.002^{ad}	5.027 ± 0.005^{d}	5.102 ± 0.003
Treatment Mean	4.281 ± 0.001	4.195 ± 0.009	
Lipolytic count			
0 day	2.944 ± 0.001^{cf}	2.846 ± 0.001^{f}	2.896 ± 0.001
7 day	3.609 ± 0.005^{be}	3.511 ± 0.004^{e}	3.560 ± 0.004
14 day	4.077 ± 0.031^{ad}	3.971 ± 0.014^{d}	4.028 ± 0.022
Treatment Mean	3.543 ± 0.012	3.442 ± 0.006	
Coliform count			
0 day	ND	ND	ND
7 day	0.682 ± 0.001^{be}	0.631 ± 0.001^{e}	0.656 ± 0.001
14 day	1.239 ± 0.001^{ad}	1.180 ± 0.155^{d}	1.209 ± 0.078
Treatment Mean	0.640 ± 0.001	0.603 ± 0.001	
Yeast and Mold count			
0 day	ND	ND	ND
7 day	0.682 ± 0.001^{be}	0.631 ± 0.001^{e}	0.656 ± 0.001
14 day	1.239 ± 0.001^{ad}	1.180 ± 0.155^{d}	1.209 ± 0.078
Treatment Mean	0.640 ± 0.001	0.603 ± 0.001	

*Mean values bearing same or no superscript row wise do not differ significantly (P<0.05).

detected on 0th day in all groups but on 7th day onward it was detected in Con and VT45 group. The overall mean value of yeast and mold count for VT45 group was found to be 1.180±0.155 log cfu/g and for Con group it was 1.239±0.001 log cfu/g (Table 7). There was significant increase in yeast and mold count from 7^{t}h day to 14th day of observation period. Sharma (1999) reported yeast and mold counts of chicken products to be very low at the time of preparation of product but, increased as high as 3.82 log cfu/gm during refrigeration storage. Biswas et al., 2006 reported that fungi got upper hand over bacteria in meat and meat products.

A significant declining trend for appearance/color score was observed with the advancement of storage period (Table 8). The overall mean for appearance/color score was found to be 6.240±0.023 for Con group at 14th day and for treatment it was 6.616±0.050. Jacobson and Koehler, 1970 reported that all the sensory quality values decreased significantly with the advancement of storage period. A declining trend for flavor score was observed in both groups with the advancement of storage period. The overall mean value for VT45 group was found to be 6.394±0.063 on 0th day and a drastic decrease in flavor score was observed on 14th day of observation (Table 8). Nath (1992) also stated that pronounced flavor changes were observed in refrigerated samples at 4℃. The TBA values correlated significantly with flavor changes indicating that oxidative changes occurred as flavor deterioration during refrigerated storage.

A significant decreasing trend in the mean value for texture during storage period was observed which were 7.019±0.011 on 0th day and 6.092±0.011 on 14th day of observation (Table 8). A significant reduction in the juiciness score was observed with the advancement of storage period. On 0th day of observation the overall mean value for juiciness in Con was 5.996±0.038 and 7.229±0.019 for VT45 group and on 14th day of observation it was reduced to 5.481±0.038 and 6.493±0.020 respectively (Table 8). The overall acceptability no doubt, decreased during storage, for both samples. These findings are in agreement with those of Mandal (1993.). On going through the above findings, it can be concluded that for preparation of chicken tikka, with the use of vacuum tumbling, the product vacuum tumbled for 45 min improved the physico-chemical, microbiological and sensory quality of the product and it can be stored at refrigeration temperature for 14 day in LDPE bags with good overall acceptability.

Table 8. Effect of treatment and control on sensory attributes of chicken tikka during storage.

Storage period	Treatment		
	Control	Vacuum tumbled (VT45)	Day mean
Appearance/color			
0 day	6.411 ± 0.015[a]	6.777 ± 0.047[da]	6.594 ± 0.031
7 day	6.341 ± 0.023[b]	6.716 ± 0.053[db]	6.528 ± 0.038
14 day	0.240 ± 0.023[c]	6.616 ± 0.050[cc]	6.428 ± 0.036
Treatment Mean	6.330 ± 0.020	6.703 ± 0.050	
Flavor			
0 day	6.019 ± 0.109[a]	6.394 ± 0.063[da]	6.206 ± 0.086
7 day	5.636 ± 0.305[b]	6.012 ± 0.063[ea]	5.824 ± 0.184
14 day	4.896 ± 0.109[c]	5.270 ± 0.062[fc]	5.083 ± 0.085
Treatment Mean	5.517 ± 0.174	5.892 ± 0.062	
Texture			
0 day	6.015 ± 0.027[a]	7.019 ± 0.011[da]	6.517 ± 0.019
7 day	5.925 ± 0.251[a]	6.674 ± 0.012[ea]	6.299 ± 0.131
14 day	5.340 ± 0.251[b]	6.092 ± 0.011[fb]	5.716 ± 0.131
Treatment Mean	5.760 ± 0.176	6.595 ± 0.011	
Juiciness			
0 day	5.996 ± 0.038[a]	7.229 ± 0.019[da]	6.613 ± 0.028
7 day	5.635 ± 0.038[b]	6.870 ± 0.279[eb]	6.252 ± 0.158
14 day	5.481 ± 0.038[c]	6.718 ± 0.020[ec]	5.987 ± 0.029
Treatment Mean	5.704 ± 0.038	6.846 ± 0.106	
Overall acceptability			
0 day	6.118 ± 0.031[a]	6.991 ± 0.016[da]	6.554 ± 0.023
7 day	5.635 ± 0.034[b]	6.521 ± 0.023[eb]	6.252 ± 0.028
14 day	5.342 ± 0.037[c]	6.227 ± 0.022[fc]	6.106 ± 0.029
Treatment Mean	5.699 ± 0.034	6.579 ± 0.020	

***Mean values bearing same or no superscript row wise do not differ significantly ($P<0.05$).

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