

## EFFECT OF VACUUM TUMBLING ON QUALITY OF TANDOORI TURKEY BREAST

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**Abstract:** The present study evaluated the effect of vacuum tumbling on the physicochemical and sensory characteristics of tandoori turkey breast. Marinated turkey breast samples were subjected to vacuum tumbling for 30 min, 1 hr, 1.5 hr and 2 hr, while marinated samples without tumbling served as the control. Vacuum tumbling significantly ( $P < 0.05$ ) increased pH, batter pickup, product yield, water-holding capacity, moisture retention and moisture content, while significantly reducing cooking loss and oil uptake. Protein and fat contents were not significantly affected by the treatments. Sensory attributes, including appearance and colour, flavour, juiciness, texture, tenderness and overall acceptability, improved significantly with increasing tumbling duration up to 1.5 hr, followed by a slight decline at 2 hr. Among the treatments, vacuum tumbling for 1.5 hr produced the most desirable physicochemical and sensory characteristics. The improved product quality was attributed to enhanced extraction of salt-soluble proteins, increased water-binding capacity and better penetration of marinade ingredients under vacuum conditions. The findings indicate that vacuum tumbling for 1.5 hr is an effective technique for improving marinade absorption, cooking yield and sensory quality of tandoori turkey breast.

**Keywords:** Vacuum tumbling, tandoori turkey breast, marination, physico-chemical characteristics, sensory quality.

### INTRODUCTION

Tandoori products are popular traditional meat preparations known for their characteristic colour, flavour, and desirable textural attributes. Marination is a critical processing step in the preparation of tandoori products, as it enhances tenderness, juiciness, flavour and overall consumer acceptability. The incorporation of curd, spices, condiments, and organic acids during marination improves both the sensory and functional properties of meat products (Hari Raj *et al.*, 2026)

Vacuum tumbling is a widely adopted marination technique in the meat industry that enhances the penetration and uniform distribution of marinade ingredients within muscle tissues. During tumbling, meat pieces rotate and repeatedly impact the drum surface, resulting in disruption of muscle structure and extraction of salt-soluble proteins, which

improve water-binding capacity and product cohesiveness. The application of vacuum further facilitates the removal of entrapped air and promotes protein extraction, thereby enhancing marinade uptake, cooking yield and tenderness (Bishnoi *et al.*, 2017). Previous studies have demonstrated the beneficial effects of vacuum tumbling on meat quality. Bharti *et al.* (2011) reported improvements in cooking yield, moisture retention and sensory characteristics of chicken tikka, while Gao *et al.* (2015) observed enhanced tenderness, juiciness, flavour and overall acceptability in prepared pork chops. Similarly, U-chupaj *et al.* (2017) reported improved marinade uptake and water-holding capacity in poultry meat products subjected to vacuum tumbling.

Turkey breast meat is valued for its high protein content and relatively low fat content. However, its dense muscle fibre structure may limit the effective penetration of marinade ingredients. Therefore, optimization of tumbling duration is essential to maximize marinade absorption and improve product quality without causing excessive softening of muscle tissues (Ge *et al.*, 2022). Although the effects of vacuum tumbling have been extensively studied in chicken and pork products, information on its application in tandoori turkey products remains limited. Hence, the present study was undertaken to evaluate the effect of different vacuum tumbling durations on the physicochemical and sensory characteristics of tandoori turkey breast.

## **MATERIALS AND METHODS**

### ***Procurement of raw materials***

Turkey birds of approximately 18 weeks age were procured from the Instructional Livestock Farm Complex and slaughtered following standard hygienic procedures. Breast muscles were separated manually and cut into uniform sized portions for preparation of tandoori turkey breast.

### ***Marinade formulation***

The marinade formulation consisted of turkey breast (100%), curd (50%), salt (2.5%), lime juice (2.5%), ginger paste (1.5%), garlic paste (1.5%), spice mixture (3.5%) and butter for surface application during cooking.

### ***Vacuum tumbling treatments***

The turkey breast samples were randomly divided into five treatment groups comprising control (without tumbling), T1 (30 min vacuum tumbling), T2 (1 hr vacuum tumbling), T3 (1.5 hr vacuum tumbling) and T4 (2 hr vacuum tumbling). The weighed quantity of turkey breast along with the prepared marinade solution was placed in a vacuum tumbler and

subjected to tumbling under vacuum conditions according to the respective treatment schedule. Control samples were marinated without tumbling.

### ***Preparation of tandoori turkey breast***

After tumbling, the samples were kept under refrigerated conditions for equilibration and cooked in an electric tandoor oven at approximately 250°C for 20–30 minutes until properly cooked. Butter was applied intermittently during cooking to improve surface appearance and flavour.

### ***Physico-chemical analysis***

The pH of samples was measured using a digital pH meter. Batter pickup percentage, product yield, cooking loss, water holding capacity, moisture retention and oil uptake values were estimated using standard procedures. Moisture, protein and fat contents were determined according to AOAC (1995) methods.

### ***Sensory evaluation***

Sensory evaluation was conducted by an experienced panel using a 9-point hedonic scale wherein 1 = extremely undesirable and 9 = extremely desirable. The sensory attributes evaluated were appearance and colour, flavour, juiciness, texture, tenderness and overall acceptability.

### ***Statistical analysis***

The experiment was repeated six times and the data generated were analyzed statistically following standard procedures.

## **RESULTS AND DISCUSSION**

### ***Physico-chemical characteristics***

The physicochemical characteristics of tandoori turkey breast subjected to different vacuum tumbling durations are presented in Table 1. A significant ( $P < 0.05$ ) increase in pH was observed with increasing tumbling duration. The higher pH values in vacuum-tumbled samples might be attributed to improved penetration and uniform distribution of marinade ingredients within the muscle tissues. Enhanced extraction of salt-soluble proteins during tumbling might contributed to the observed increase in pH (Wang *et al.*, 2025). Similar findings have been reported by Bharti *et al.* (2011) in chicken tikka and Gao *et al.* (2015) in prepared pork products, where vacuum tumbling resulted in increased pH values and improved product quality.

**Table 1: Effect of vacuum tumbling on physico-chemical characteristics of tandoori turkey breast (Mean  $\pm$  S.E)**

| Physico-chemical characteristics* | Control                       | 30 minutes                    | 1 hour                        | 1.5 hours                     | 2 hours                       |
|-----------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| pH                                | 6.12 $\pm$ 0.12 <sup>a</sup>  | 6.24 $\pm$ 0.10 <sup>b</sup>  | 6.32 $\pm$ 0.10 <sup>c</sup>  | 6.40 $\pm$ 0.12 <sup>d</sup>  | 6.44 $\pm$ 0.10 <sup>d</sup>  |
| Batter pickup (%)                 | 5.40 $\pm$ 0.10 <sup>a</sup>  | 7.82 $\pm$ 0.14 <sup>b</sup>  | 10.24 $\pm$ 0.12 <sup>c</sup> | 13.62 $\pm$ 0.14 <sup>d</sup> | 14.08 $\pm$ 0.12 <sup>d</sup> |
| Product yield (%)                 | 72.76 $\pm$ 0.12 <sup>a</sup> | 74.84 $\pm$ 0.14 <sup>b</sup> | 77.18 $\pm$ 0.15 <sup>c</sup> | 79.86 $\pm$ 0.12 <sup>d</sup> | 80.12 $\pm$ 0.14 <sup>d</sup> |
| Cooking loss (%)                  | 27.24 $\pm$ 0.12 <sup>e</sup> | 25.16 $\pm$ 0.14 <sup>d</sup> | 22.82 $\pm$ 0.15 <sup>c</sup> | 20.14 $\pm$ 0.12 <sup>b</sup> | 19.88 $\pm$ 0.14 <sup>a</sup> |
| Water holding capacity (%)        | 42.18 $\pm$ 0.12 <sup>a</sup> | 44.24 $\pm$ 0.14 <sup>b</sup> | 46.18 $\pm$ 0.16 <sup>c</sup> | 48.42 $\pm$ 0.14 <sup>d</sup> | 48.68 $\pm$ 0.12 <sup>d</sup> |
| Moisture retention (%)            | 57.70 $\pm$ 0.12 <sup>a</sup> | 58.84 $\pm$ 0.14 <sup>b</sup> | 60.12 $\pm$ 0.12 <sup>c</sup> | 62.84 $\pm$ 0.10 <sup>d</sup> | 63.08 $\pm$ 0.12 <sup>d</sup> |
| Oil uptake (%)                    | 10.24 $\pm$ 0.12 <sup>e</sup> | 9.18 $\pm$ 0.14 <sup>d</sup>  | 8.36 $\pm$ 0.12 <sup>c</sup>  | 7.42 $\pm$ 0.14 <sup>b</sup>  | 7.16 $\pm$ 0.12 <sup>a</sup>  |
| Moisture (%)                      | 65.28 $\pm$ 0.12 <sup>a</sup> | 68.16 $\pm$ 0.14 <sup>b</sup> | 71.24 $\pm$ 0.14 <sup>c</sup> | 74.62 $\pm$ 0.12 <sup>d</sup> | 74.88 $\pm$ 0.14 <sup>d</sup> |
| Protein (%)                       | 23.12 $\pm$ 0.12              | 23.34 $\pm$ 0.14              | 23.58 $\pm$ 0.12              | 23.86 $\pm$ 0.15              | 23.92 $\pm$ 0.14              |
| Fat (%)                           | 8.10 $\pm$ 0.15               | 8.26 $\pm$ 0.12               | 8.54 $\pm$ 0.14               | 8.82 $\pm$ 0.16               | 8.88 $\pm$ 0.14               |

\*Number of observations = 6

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

Batter pickup increased significantly ( $P < 0.05$ ) with increasing vacuum tumbling duration. The enhanced extraction of salt-soluble proteins and increased permeability of muscle tissues during tumbling might facilitated greater marinade absorption and retention. Similar observations were reported by U-chupaj *et al.* (2017), who observed increased marinade uptake in vacuum-tumbled poultry products. Product yield increased significantly ( $P < 0.05$ ) with increasing tumbling duration, whereas cooking loss decreased significantly. Improved water-binding capacity and enhanced retention of marinade solution during tumbling might be contributed to the higher yields and reduced cooking losses (Lu *et al.*, 2025). These findings are consistent with those of Bharti *et al.* (2011), Popat *et al.* (2016) and Gao *et al.* (2015), who reported increased cooking yield and reduced cooking losses in vacuum-tumbled meat products. Water-holding capacity and moisture retention also increased significantly ( $P < 0.05$ ) with increasing tumbling duration. Vacuum tumbling promotes the extraction of salt-soluble proteins, resulting in improved water binding within the muscle structure. Bishnoi *et al.* (2017) reported that the formation of protein exudates during tumbling enhances cohesiveness and water-holding capacity in meat products. Oil uptake values decreased significantly ( $P < 0.05$ ) in vacuum-tumbled samples compared with the control. The increased moisture retention and formation of a stable protein matrix during tumbling might reduced oil penetration during cooking (Lu *et al.*, 2025). Moisture content increased significantly ( $P < 0.05$ ) with increasing tumbling duration, reflecting greater uptake and retention of marinade solution. In contrast, protein and fat contents did not differ significantly

among treatments. Similar findings have been reported in vacuum-tumbled goat meat rolls and chicken products (Yadav *et al.*, 2014; Bharti *et al.*, 2011). Among the treatments, vacuum tumbling for 1.5 hr produced the most desirable physicochemical characteristics, with superior moisture retention and product yield. A slight decline in quality parameters observed after 2 hr of tumbling may be attributed to over-tumbling, which can cause excessive disruption of muscle fibres and adversely affect product structure.

### ***Sensory characteristics***

The sensory characteristics of tandoori turkey breast subjected to different vacuum tumbling durations are presented in Table 2. Significant ( $P < 0.05$ ) differences were observed among treatments for all sensory attributes evaluated. Appearance and colour scores increased significantly ( $P < 0.05$ ) with increasing tumbling duration up to 1.5 hr, followed by a slight decline in samples tumbled for 2 hr. The improved penetration and uniform distribution of marinade ingredients during tumbling might contributed to the enhanced appearance and colour of the products. Similar observations were reported by Singh *et al.* (2018) and Gao *et al.* (2015). Flavour scores also increased significantly ( $P < 0.05$ ) with increasing tumbling duration up to 1.5 h. Enhanced absorption and distribution of spices, condiments and curd within the muscle tissues likely improved flavour development. Comparable findings have been reported by Bharti *et al.* (2011) and Singh *et al.* (2018) in vacuum-tumbled chicken products. Juiciness scores were significantly higher ( $P < 0.05$ ) in vacuum-tumbled samples than in the control. The increased moisture retention and water-holding capacity observed in vacuum-tumbled products might be contributed to their superior juiciness and improved eating quality. Texture and tenderness scores improved significantly ( $P < 0.05$ ) with increasing tumbling duration up to 1.5 hr. However, a slight decline in these attributes was observed after 2 hr of tumbling, which may be attributed to excessive softening of muscle tissues resulting from prolonged mechanical action. Similar trends have been reported in marinated chicken and pork products subjected to extended tumbling treatments (Gao *et al.*, 2015; Singh *et al.*, 2018). Overall acceptability scores were significantly ( $P < 0.05$ ) higher in vacuum-tumbled products than in the control samples. Among the treatments, tandoori turkey breast subjected to vacuum tumbling for 1.5 hr received the highest overall acceptability score. The improved acceptability might be attributed to enhanced flavour, tenderness and juiciness resulting from more effective marinade absorption and increased extraction of salt-soluble proteins during tumbling. These findings indicate that vacuum tumbling for 1.5 hr is

the optimum treatment for producing tandoori turkey breast with superior sensory quality characteristics.

**Table 2: Effect of vacuum tumbling on sensory characteristics of tandoori turkey breast (Mean  $\pm$  S.E)**

| Sensory characteristics** | Control                      | 30 minutes                   | 1 hour                       | 1.5 hours                    | 2 hours                      |
|---------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| Appearance and colour     | 7.42 $\pm$ 0.14 <sup>a</sup> | 7.86 $\pm$ 0.12 <sup>b</sup> | 8.24 $\pm$ 0.14 <sup>c</sup> | 8.68 $\pm$ 0.12 <sup>d</sup> | 8.32 $\pm$ 0.14 <sup>c</sup> |
| Flavour                   | 7.18 $\pm$ 0.12 <sup>a</sup> | 7.64 $\pm$ 0.14 <sup>b</sup> | 8.12 $\pm$ 0.12 <sup>c</sup> | 8.54 $\pm$ 0.14 <sup>d</sup> | 8.18 $\pm$ 0.12 <sup>c</sup> |
| Juiciness                 | 7.06 $\pm$ 0.12 <sup>a</sup> | 7.82 $\pm$ 0.14 <sup>b</sup> | 8.28 $\pm$ 0.12 <sup>c</sup> | 8.72 $\pm$ 0.14 <sup>d</sup> | 8.36 $\pm$ 0.12 <sup>c</sup> |
| Texture                   | 7.18 $\pm$ 0.14 <sup>a</sup> | 7.74 $\pm$ 0.12 <sup>b</sup> | 8.16 $\pm$ 0.14 <sup>c</sup> | 8.58 $\pm$ 0.12 <sup>d</sup> | 8.22 $\pm$ 0.14 <sup>c</sup> |
| Tenderness                | 7.12 $\pm$ 0.12 <sup>a</sup> | 7.86 $\pm$ 0.14 <sup>b</sup> | 8.22 $\pm$ 0.12 <sup>c</sup> | 8.64 $\pm$ 0.14 <sup>d</sup> | 8.28 $\pm$ 0.12 <sup>c</sup> |
| Overall acceptability     | 7.18 $\pm$ 0.12 <sup>a</sup> | 7.84 $\pm$ 0.14 <sup>b</sup> | 8.26 $\pm$ 0.12 <sup>c</sup> | 8.62 $\pm$ 0.14 <sup>d</sup> | 8.24 $\pm$ 0.12 <sup>c</sup> |

\*\*Number of observations = 42

Sensory attributes were evaluated on a 9-point hedonic scale wherein 1 = extremely undesirable and 9 = extremely desirable.

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

## CONCLUSION

Vacuum tumbling significantly improved the physicochemical and sensory characteristics of tandoori turkey breast. Increasing tumbling duration enhanced batter pickup, product yield, water-holding capacity, moisture retention and moisture content, while reducing cooking loss and oil uptake. Sensory attributes improved up to 1.5 hr of tumbling but showed a slight decline after 2 hr due to over-softening of muscle tissues. Among the treatments, vacuum tumbling for 1.5 hr produced the most desirable physicochemical and sensory characteristics. Therefore, vacuum tumbling for 1.5 hr recommended for the production of high-quality tandoori turkey breast with enhanced consumer acceptability.

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