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EFFECT OF VACUUM TUMBLING ON COOKING YIELD AND PHYSICAL PROPERTY OF TANDOORI CHICKEN

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Abstract: A study was conducted to assess the cooking yield and physical property of tandoori chicken prepared from aseel meat by marinating the chicken breast meat at different vacuum tumbling time exposures, giving rise to five treatments *viz.* T_0 (Control-No tumbling), T_1 (30 minutes), T_2 (1 hour), T_3 (2 hours) and T_4 (3 hours). After marination, the samples were immediately cooked for 10-20 minutes at 250°C to prepare tandoori chicken breast meat. Fresh meat and product were subjected to study the physical parameters. The whole design was replicated twelve times. Product having 2 hrs tumbling time have shown highly significant difference ($P \geq 0.01$) for cooking yield and marinate uptake. For Tandoori meat 2 hrs tumbling product have very low Shear force value ($P \geq 0.01$). There is no significant difference for color but more tumbling time product has better color than others. Thus, marination at 2 hours vacuum tumbling followed by 10-20 minutes cooking at 250°C were considered to be ideal for the production of better quality tandoori chicken.
Keywords: Tandoori, Tumbler, broiler, marinating, Shear force value.

Introduction

India’s current level of meat and meat-based exports is around Rs. 8,000 million. Only about 1 percent of the total meat is converted into value added products like sausages, ham, bacon, luncheon meat, kababs, meat balls etc. There was increasing demand for meat products suitable for fast food consumption, it would be beneficial to develop easy to prepare, simple, less cost value added and processed meat products which can improved nutritive values thus providing health benefits for consumers (Gurikar et al., 2014). Marinade solutions usually contain a complex solution of water, salts, spice, coriander, curd, onian, garlic, Chili powder, turmeric powder, cinnamom and other ingredients and are applied to the meat by soaking, blending, tumbling or injection. It is well known that marination is a popular technique used to tenderize and improve the quality characteristics of meat products.

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Various new techniques have been introduced to accelerate marinade transport throughout the meat. As a kind of physical-mechanical treatment, tumbling is well recognized and accepted (Pietrasik and Shand, 2003). The combination of marination and tumbling provides a useful means of loosening the muscle structures, disrupting muscle cells and destroying the connection between the myofibers and the connective tissue. Also, it promotes the degradation of sarcomere I-filaments and Z-lines, thus facilitating the uniform penetration of the marinade into meat by extracting salt soluble proteins (SSP) (Cassidy et al., 1978). Tumbling of meat is usually performed using a vacuum tumbler, which promotes marinade solution penetration and improves color stability of meat. Tumbling treatments are either continuous or intermittent. 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. Tumbling has many beneficial effects, some of which are due to the formation of protein exudates. 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 tender.

Kumar and Berwal (1996) described that the tandoori chicken was a traditional, delicious non-vegetarian product of India and it was prepared by roasting of spiced and seasoned chicken in an earthen oven called “tandoor”. Tandoori chicken is the traditional meat product made from the poultry meat. The demand for this product is increasing in urban and metro cities. This has created a necessity for mass scale production of tandoori chicken. But aged and native birds are not suitable for tandoori preparation because of tenderness. There is a need to improve processing in such a way that it will improve the tenderness.

Materials and Methods

For the present study, breast meat obtained from native chicken of same hatch and age of 12 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 skews 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 physical 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

Cooking yield: Individual weight of marinated carcasses before and after cooking was recorded.

Cooking yield =	Weight of tandoori chicken after cooking / Weight of marinated carcass before cooking	X100

Cooking loss:

Cooking loss =	Weight of marinated carcass before cooking - Weight of tandoori chicken after cooking / Weight of marinated carcass before cooking	X100

Hunter colour analysis: Colour of meat sample was measured using Hunter lab Mini scan XE plus Spectro-colorimeter (Model No. 45/O-L, Reston Virginia, USA) with geometry of diffuse/80 (sphere – 8mm view) and an illuminant of D65/10 deg.

Shear Force Value (Kg/cm2): Shear force value of the product was measured by a modified method described by Khan (1971).

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, Turkey's HSD test was conducted by a SPSS® – 20 software package.

Result and discussion

The abbreviations used in results for treatments and control is as follows for control: Con; 30 min tumbling: T1, 60 min tumbling: T2 and 120min tumbling: T3, 180min tumbling: T4. Data presented in Table 2 indicate that there is no significant difference in live weight, dressed weight, dressing percentage between treatment group and control group.

Cooking Yield of Tandoori Chicken from Native Chicken Meat (n=24)

Parameter	Live weight (gm)	Dressed weight (gm)	Dressing (%)	Weight of marination + carcass (gm)	Marination uptake (gm)	Cooking weight (gm)	Cooking yield (%)
Control	1730.71 ± 16.16	927.50 ± 17.27	53.54 ± 0.73	1039.83[b] ± 19.74	112.33[a] ± 4.76	609.58[a] ± 15.70	58.46[a] ± 0.59
T1	1585.83 ± 23.58	827.08 ± 20.39	52.38 ± 1.49	960.00[a] ± 21.51	132.92[b] ± 4.64	638.67[a] ± 16.07	66.73[b] ± 1.30
T2	1764.88 ± 18.72	923.63 ± 29.32	52.10 ± 1.14	1082.71[c] ± 26.02	159.08[c] ± 7.39	734.33[b] ± 15.56	67.82[b] ± 1.14
T3	1604.50 ± 14.69	943.50 ± 19.61	58.67 ± 0.81	1142.50[c] ± 18.45	199.00[c] ± 5.34	785.71[b] ± 16.63	73.14[b] ± 1. 84

T4	1454.88 ± 27.82	888.46 ± 24.78	60.84 ± 0.57	1076.21^{ab} ±20.77	187.75^{c} ± 6.96	746.83^{b} ± 16.15	69.39^{b} ± 1.02
F Value	35.68NS	4.20NS	15.75NS	12.19**	55.74**	27.73**	21.96**

Column bearing different superscripts differ significantly, n= number of observations
*-Significant (P<0.05); **- Highly Significant (P<0.01)

Marinate uptake (gm): There was highly significant difference between control and treatment. High marinate uptakes were found in T3 i.e 199.00 ± 5.34; by increasing tumbling time -there is marinate also increased and this result coincides with the finding of (Ledward, 1979) who reported that marinate uptake increased when tumbling time increased. Rust and Olson (1973) felt that the exudates of myofibrillar protein seals moisture in the product as it coagulate on and immediately below the surface which avoid solution loss during cooking. Vartorella (1975) and Krause (1976) also reported that the protein exudates help holding juices during smoking and cooking, and results in increased yields, increased juiciness, and improved slicing characteristics of the finished product. Theno *et al.* (1978) 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. Ghavimi *et al*. (1986) and Pohlman *et al*., (2002) reported that meat surface was destructured by tumbling and transfer surface area was likely to increase. Consequently, tumbling would enhance water and acid transport between meat and solution. Marinade penetration and diffusion are therefore accelerated.

Cooking yield (%):

There was highly significant difference between control and treatment. By increasing tumbling time, cooking weight is also increasing. Cooking yield of Tandoori Vacuum Tumbled for 120 min was significantly (P<0.01) higher than the Control, and other group. This result is agree with 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. Hence more cooking yield was due to excess water holding and marinate uptake along with tumbling.

Colour and Shear Force Value of Native Chicken Meat Tandoori (n=24)

Parameter	Lightness		Redness		Yellowness		Shear Force Value (Kg/cm^2)	
	Fresh Meat	Product	Fresh Meat	Product	Fresh Meat	Product	Fresh Meat	Product
Control	61.61 ± 0.18	57.17 ± 1.38	8.57 ± 0.50	28.01^{a} ± 0.46	15.25 ± 0.09	39.00 ± 0.16	6.76 ± 0.15	4.28^{c} ± 0.37
T1	61.85 ± 0.22	58.29 ± 1.23	6.38 ± 0.15	29.96^{ab} ± 0.52	15.19 ± 0.19	37.64 ± 1.44	5.89 ± 0.29	2.77^{b} ± 0.29
T2	60.59 ± 0.41	59.30 ± 0.50	7.06 ± 0.19	31.60^{bc} ± 0.49	15.43± 0.18	39.46 ± 0.48	6.44 ± 0.18	2.48^{ab} ±0.21
T3	58.51 ± 0.28	59.32 ± 0.31	7.44 ± 0.14	31.14^{bc} ± 1.29	15.68 ± 0.15	40.41 ± 0.40	7.05 ± 0.26	1.79^{a} ± 0.37
T4	62.18 ± 0.51	60.08 ± 0.47	7.46 ± 0.14	32.98^{c} ± 0.43	15.36 ± 0.19	39.72 ± 0.51	6.66 ± 0.16	1.56^{a} ± 0.34
F Value	1.94^{NS}	1.56^{NS}	0.50^{NS}	6.82**	1.31^{NS}	1.95^{NS}	3.99^{NS}	11.09**

Column bearing different superscripts differ significantly. n= number of observations
NS-Not significant (P>0.05); **- Highly Significant (P<0.01)

Lightness: There was no significant difference between control and treatment. Lightness was reduced in products as compared to fresh meat. In this study lightness was reduced in product as compared to fresh meat as stated by Qiao et al., (2002), due to the marinate ingredient lightness was reduced and cooking as reported by Serdaroglu, 2005 and Qiao et al., (2002). Lightness of meat product was positively correlated with cooking loss and negatively correlated with water holding capacity (Barbut, 1993). According to Barbut (1993) lightness of raw fillets was positively correlated with cooking loss and negatively correlated with water holding capacity. Allen *et al.* (1998) reported that lightness increased when fillets with light-to-dark-colour variations were marinated and that marination was affected by the colour of the meat. Tumbling improved uniform cured meat colour (Krause, 1976).

Redness: There was significant difference between control and treatment observed both in fresh meat and product obtained from that meat. Redness was increased in products as compared to fresh meat. The colour of cooked meat products arise mainly from pigmentation of the meat from which they were made and the ingredients used in the processing (Serdaroglu, 2005). Redness was an important characteristic for consumer acceptance (Maga, 1994). Absolute colour values changed with marination and cooking (Qiao et al., 2002).

Extreme colour variations, from very light to very dark, had significant effects on functional properties and chemical composition of broiler breast meat (Qiao et al., 2001).

Yellowness: There was no significant difference between control and treatment observed both in fresh meat and product obtained from that meat. Yellowness was increased in products as compared to fresh meat. Product colour may be due to the ingredient used and cooking.

Shear Force Value: There was significant difference between control and treatment observed in fresh meat. In this study shear force value was decreased in product as compared to raw meat and in case of product as compared to control product have less shear force value. Toughening effect was due to hardening of myofibrillar proteins (Laakkonen, 1973). Greater variability in shear values of raw samples as compared to those of cooked meat was observed by McBee and Naumann (1959). According to Krause (1976), tumbling improved tenderness and more uniform cured meat colour. Improvement in shear force value in tumbled product might be due to cellular disruption and myofibrillar fragmentation of the muscle tissue (Babji et al., 1982). McBee and Naumann (1959) noted a greater variability in shear values of raw samples as compared to those of cooked meat.

Bouton *et al.* (1971) concluded that changes in myofibrillar structure resulted in increases in shear values over the temperature range of 40 to 60°C and 80°C, and the increases were dependent on muscle contraction state in the former, but not the latter temperature range. Bouton *et al.* (1977) found that combined pressure heat treatments lead to a substantial decrease in shear force, even in cold-shortened meat. Narasimha Rao (1996) reported that the optimum Warner- Bratzler shear value for tandoori chicken was 2.10 kg/cm' and the shear stress decreased with increase in cooking time and temperature irrespective of the length of marination.

Conclusion: Two hour tumbling help to improve marinate uptake, cooking yield, redness and shear force value. Thus, marination at 2 hours vacuum tumbling followed by 10-20 minutes cooking at 250°C were considered to be ideal for the production of better quality tandoori chicken for commercial and large scale production.

References

[1] Allen, C.D., D.L. Fletcher, J.K. Northcutt and S.M. Russell, 1998. The relationship of broiler breast colour to meat quality and shelf-life. *Poult. Sci*. **77:**361–366

[2] Babji, A.S., G.W. Froning and D.A. Ngoka, 1982. The effect of short term tumbling and salting on the quality of turkey breast meat. *Poult. Sci.* **61**: 300-303.

[3] Barbut, S., 1993. Colour measurements for evaluating the pale soft exudative (PSE) occurrence in turkey meat. *Food Res. Int.* **26**: 39–43.

[4] Bouton, P.E., A.L. Ford, P.V. Harris, J.J. Macfarlane and J.M.O. Shea, 1977. Pressure heat treatment effect on tenderness of post-vigor muscle. *J. Food Sci.* **12:**132-135.

[5] Bouton, P.E., P.V. Harris and D. Ratcliff, 1971. Effect of cooking temperature and time properties of meat. *J. Food. Sci.* **46:** 1082.

[6] Cassidy RO, Ockerman HW, Krol B, Van Roon PS, Plimpton RF, Cahill VR. Effect of tumbling method, phosphate level and final cook temperature on histological characteristics of tumbled porcine muscle tissue. J Food Sci. 1978; 43: 1514–1518.

[7] Dzudie. T and A. Okubanjo, 1999. Effect of rigor state and tumbling time on quality of goat hams. *J. Food Engr.* **42**: 103-107.

[8] Ghavimi B., R.W. Roigers, T.G. Althan and G.R. Ammerman, 1986. Effects of non-vacuum, vacuum and nitrogen back flush tumbling on various characteristics of restructured cured beef. *J. Food Sci.* **51**: 1166- 1168.

[9] Gurikar AM, Lakshmanan V, Gadekar YP, Sharma BD, Anjaneyulu ASR. Effect of meat chunk size, massaging time and cooking time on quality of restructured pork blocks. J Food Sci Technol. 2014;51: 1363–1369.

[10] Khan, A.W., 1971. Effect of temperature during post-mortem glycolysis and dephosphorylation of high energy phosphates on poultry meat tenderness. *J. Food Sci.* **36**: 120-121(Quoted in *Poultry. Sci*. **68:**1588-1591).

[11] Krause, R., 1976. Influence of tumbling and sodium trio polyphosphate on quality, yield, and cure distribution in hams. M. Sc. Dissertation. The Ohio State University, Columbus, OH. USA.

[12] Kumar, M and J.S. Berwal, 1996. Hurdle technology for a shelf stable tandoori chicken. In proceedings of the XX Worlds poultry congress, New Delhi. India. **111**: 149-155.

[13] Laakkonen, E. 1973. Factors effecting tenderness during heating of meat. In C.O. Chichester E. M. Mrak and G. F. Stewart (ed) *Advances in Food Research.* **20:** 257-323.

[14] Ledward DA., 1979. Meat. Effect of heating on foodstuffs. In R.J. Priestley (ed.). London: Applied Science Publishers, pp. 121-157

[15] Maga, J.A., 1994. Pink discoloration in cooked white meat. *Food Rev. Int*. **10:** 273–286.

[16] Mc Bee and H.D. Nauman, 1959. The influence of freezing on shear and taste panel evaluation of beef. J. Anim. Sci., 18: 1471.

[17] Muller, W.B., 1991. Effect of method of manufacture. Fleischwirtschaft. **71**: 8, 10-18, 60.

[18] Narasimha Rao., 1996. Assessment of physical, chemical and microbial attributes in traditional Indian Poultry Products Tandoori and Kabab. In proceedings of the *XX world's poultry congress*. New Delhi, India. **111**: 57-64.

[19] Pietrasik Z, Shand PJ. The effect of quantity and timing of brine addition on water binding and textural characteristics of cooked beef rolls. Meat Sci. 2003;65: 771–778.

[20] Plimpton RF, Perkins CJ, Sefton TL, Cahill VR, Ockerman HW. Rigor condition, tumbling and salt level influence on physical, chemical and quality characteristics of cured, boneless hams. J Food Sci. 1991; 56:1514–1518.

[21] Pohlman F.W., M.R. Stivarius, K.S. McElyea and A.L. Waldroup, 2002. Reduction of *E.coli, Salmonella, Typhimurium*, Coliform, aerobic bacteria and improvement of ground beef color using trisodium phosphate or centylpyridium chloride before grinding. *Meat Sci*. **60**: 349-356.

[22] Qiao, M., D.L. Fletcher, D.P. Smith and J. K. Northcutt, 2002. Effects of Raw Broiler Breast Meat Color Variationon Marination and Cooked Meat Quality. *Poultry Science.* **81**: 276–280.

[23] Qiao, M., D.L. Fletcher, J.K. Northcutt and D. P. Smith, 2002. The relationship between raw broiler breast meat color and composition. *Poultry Sci.* (In press).

[24] Qiao, M., D.L. Fletcher, D.P. Smith, and J.K. Northcutt, 2001. The effect of broiler breast meat color on pH, water-holding capacity, and emulsification capacity. *Poultry Sci*. **80**: 676–680.

[25] Rust R.E, and D.G, Olson, 1973. Meat curing principles and modern practice. Koch supplies, Inc., Kanas city.

[26] Snedecor GW, Cochran WG (1994). Statistical methods. First East West press edition, New Delhi.

[27] Serdaroglu, M., G. Yildiz-Turp and K. Abrodimov, 2005. Quality of low fat meatballs containing legume flour as extenders. *Meat Sci.* **70**: 99-105.

[28] Theno, D.M., D.G. Siegel and G.R. Schmidt, 1978. Meat massaging effect of salt and phosphate on the ultra structure of cured porcine muscle. *J. Food Sci.* **43**: 488-492.

[29] Vartorella. T., 1975. Canned pork. M.Sc. Dissertation. The Ohio State Uni. Columbus, OH. USA.