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Effect of Cooking Methods and Fat Levels on the Physico-chemical, Processing, Sensory and Microbial Quality of Buffalo Meat Patties

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ABSTRACT : Buffalo meat patties with two fat levels, F1 (15% added fat) and F2 (5% added fat and 3% tapioca starch), were cooked in a pre-heated hot air oven (HO) at 175±2°C for 15 min, in a microwave oven (MO) for 70 sec and by pressure cooking (PC) at 15 psi pressure for 10 min. and compared for physico-chemical, processing, sensory and microbiological quality attributes. F2 had significantly ($p<0.05$) higher value for the moisture and moisture protein ratio than F1. However, MO and PC patties had significantly ($p<0.05$) higher moisture content than HO-cooked buffalo meat patties irrespective of fat content. Highest fat percentage was in MO patties while the minimum was in PC patties. Moisture and fat retention and cooking yield were highest in MO patties irrespective of added fat content in the formulation. Cooking yield and dimensional parameters were better maintained in F2 than F1. Sensory scores viz. appearance and color, flavour, juiciness and texture for HO patties were better than other cooking methods. Sensory panelists rated overall acceptability of HO patties very good to excellent, whereas PC and MO patties were rated as good to very good irrespective of fat content. Microbiological quality was comparable in both groups irrespective of cooking methods used. (**Key Words :** Microwave Cooking, Pressure Cooking, Hot Air Oven Cooking, Meat Quality, Low-fat Patties, Buffalo Meat)

INTRODUCTION

Buffalo meat (carabeef) is getting popular worldwide because it has some inherent properties over beef with respect to attributes such as lower intermuscular fat, cholesterol, calories, higher units of essential amino acids, biological value and iron content (Anjaneyulu et al., 1990). India ranks first in buffalo population in the world and contributes about 46.69% of total world's buffalo meat (FAO, 2007). Buffalo meat has good functional properties for processing into variety of meat products such as sausages (Sachindra et al., 2005), burgers (Modi et al., 2003), kababs (Hoda et al., 2002), patties (Suman and Sharma, 2003; Nissar et al., 2009; 2008) etc.

Rheological, structural and nutritional properties of the processed comminuted meat products depend heavily on the fat in the formulation and method of cooking. Fat plays a pivotal role in the formation of stable emulsion and imparts a better texture, juiciness and flavour to the comminuted meat products (Kumar and Sharma, 2004). Whereas, the method of cooking determines its compositional, processing determinants and sensory attributes especially appearance and color and juiciness of the meat product.

As per USDA and FDA guidelines suggested that patties be cooked until no pink color remained in the center and juices were clear. An internal endpoint temperature of 71.1°C was suggested for consumers and while 68.3°C with 16 sec holding time was recommended for food service operations (USDA, 1993). Ryan et al. (2006) proposed that to get the well done appearance of beef patties, the patties must be cooked rapidly to an end point temperature of atleast 82.2°C or cook to 76.7°C and hold for 1 minute or cook to 71.1°C and hold for 6 minutes.

Some workers have observed that microwave oven cooked meat products had lower moisture content than conventional oven cooking (Salama, 1993; Hoda et al., 2002); but Nath et al. (1996) and Mendiratta et al. (1998) reported no moisture difference in microwave oven and conventional oven cooked chicken patties. The aroma, flavour and palatability of hot air oven cooked products were found to be better and more acceptable as compared to microwave oven cooked products (Pawar et al., 2002). Convection oven cookery resulted in improvements in

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sensory and instrumental tenderness values compared with pre cooking and reheating of low-fat (8%) pork nuggets prepared with gums, modified food starches and 90 percent pork (Berry, 1994). Jeong et al. (2004) and Sharma et al. (2005) concluded that fat level affects the processing and sensory properties of meat patties cooked by microwave energy. The low-fat patties had lower cooking losses, less reduction in diameter, high change in thickness and higher shear force values than high-fat patties. Raj et al. (2005) asserted better microbial quality during oven cooking than microwave cooking of chevon patties. Heddleson and Doores (1994) concluded that microwave cooking with ovens of lower wattage (eg. 450 W) was less effective in destroying bacteria viz. *Salmonella*, *Staphylococcus aureus* etc. compared to cooking with ovens of higher temperature.

Therefore, the present research work has been designed to address the issues related to effect of different cooking methods and fat levels on the physico-chemical, sensory and microbiological qualities of buffalo meat patties.

MATERIALS AND METHODS

Sources of materials

Adult Murrah buffaloes of 5-7 years age were slaughtered by humane method using captive bolt pistol stunning after proper rest in the lairage and ante mortem inspection at a modern abattoir, Punjab Meats Limited, Behra, Derabassi (India). After hygienic dressing and post mortem inspection the carcass were chilled, aged and separated into wholesale cuts viz. chuck, rib, brisket, loin, sirloin. Rib, loin and sirloin cuts of forequarter were selected for the study and these were manually deboned. The entire external fascia, blood vessels, and other connective tissues were removed. The boneless meat packed in LDPE films was frozen in small unit packs of 2 kg each and was brought to the laboratory of Department of Livestock Products Technology in the insulated boxes within two hours and stored in a deep freezer at -18°C till further studies. The required portion of the frozen meat for the experiment was taken out and kept at refrigeration temperature (4±2°C) overnight for thawing and subsequently used. Tapioca starch was procured from Jemsons Starch and Derivatives, Alappuzha, Kerala, India (Moisture 10.0%; carbohydrate 98.88% on DM basis; crude protein 0.18%; crude fiber 0.08% and total ash 0.32%). The other ingredients required for the processing were procured from the local market.

Formulation and processing

The thawed lean meat was cut into small chunks and minced in a motor driven mincer of local make through 6 mm plate followed by 3 mm plate. The formulation and processing technologies of patties with lower fat content (5% added fat) incorporated with 3% tapioca starch and patties with higher fat level (15% added fat) were used in the present study as standardized by Nissar et al. (2009). Various ingredients refined wheat flour 3%, salt 1.5%, spice mix 2.0%, condiment mix 3.0%, sodium tripolyphosphate 0.3%, sugar 0.2% and sodium nitrite 120 ppm were mixed. The refined soybean oil and crushed ice was used as added fat and water in the formulation at the level of 15.0 and 5.0 and 5.0 and 12.0 percent respectively as per Nissar et al. (2009). All the ingredients except water and fat were added into the minced meat and the mixture was preblended for 18 h. The meat batter was prepared by mixing the preblended meat in a kneader-cum-blender (Inalsa make) for 90 sec. along with slow addition of ice cold water and added fat. Each patty was prepared from 75 g mix and moulded in a moulder of dimensions 75 mm diameter and 15 mm height. The buffalo meat patties were cooked by three different methods viz. hot air oven, microwave oven and pressure cooker at different time-temperature combinations.

Hot air oven cooking (HO) : The moulded raw patties were placed in stainless steel plates pre-smeared with refined soybean oil to avoid sticking and cooked in a pre-heated hot air oven (Macro Scientific Limited, New Delhi, Model MSW-211) at 175±2°C until the internal temperature of patties reached 72°C recorded at the geometrical centre of the patties using probe thermometer. Then the patties were turned upside down and cooked for another 5 min for adequate doneness and to improve the appearance and colour.

Microwave oven cooking (MO) : The microwave cooking was done in a 700 W single beam microwave oven operating at 2,450 MHz (Inalsa, Model: IMW 17 EG) for 70 sec in order to achieve an internal temperature of 72°C measured by probe thermometer.

Pressure cooking (PC) : The pressure-cooking was conducted after the raw patties were transferred to a stainless steel plate pre-smeared with refined soyabean oil. The plate was covered with aluminium foil and placed in an autoclave (Macro Scientific Limited, New Delhi, Model MSW-101) to cook the patties at 121°C at 15 lb pressure for 10 min. After cooking the patties were taken out and cooled and different observations were recorded. The samples were drawn hygienically for the evaluation of microbiological quality of the product. The cooked patties were subjected to sensory evaluation at 35±5°C and the remaining patties were packed in LDPE pouches for further studies.

Cooking characteristics

The cooking yields of the patties were determined by measuring the weight of the patties for each treatment and were calculated as the ratio of cooked weight to raw weight expressed as percentage. The percent cooking loss was calculated as the difference in weight between individual raw and cooked patties. The moisture retention value represented the amount of moisture retained in the cooked product per 100 g of raw sample. It was calculated as described by Kumar and Sharma (2004).

The thickness and height of the cooked patties was recorded using Vernier Calliper at two different points to obtain an average thickness and height, respectively and the percent gain in height and percent decrease in diameter were also determined. After recording the diameter and thickness of raw and cooked patties, the percent shrinkage was determined as per equation described by El-Magoli et al. (1996).

Physico-chemical analysis

Composition : Moisture, fat (ether extractable) and protein content of raw and cooked patties were determined according to the standard AOAC (1995) procedures using a hot air oven, a soxhlet extraction apparatus and a Kjeldahl assembly respectively.

Sensory evaluation : Patties at a temperature of 30-35°C were assessed for their appearance and colour, flavour, juiciness, texture and overall acceptability by a panel of eight experienced judges using an 8 point descriptive scale, where 8 denoted extremely desirable and 1 denoted extremely poor. Tap water was provided between samples to cleanse the palate.

Calorie value : Estimates of total calories in cooked ground buffalo patties were calculated on the basis of 100 portion using the Atwater values for fat (9 kcal/g), protein (4.02 kcal/g) and carbohydrate (4 kcal/g). The calories contributed by tapioca starch was based on the level of incorporation and composition. An analysis of the percentage of carbohydrate in the meat samples was not performed; the calorie values were estimates and not actual values.

Microbiological quality : Microbiological quality of the developed patties was evaluated on basis of estimation of standard plate count, psychrotrophic plate count and Coliforms count (APHA, 1984).

Statistical analysis

For consistency, duplicate samples were taken for each parameter and each experiment was repeated three times, total being six observations (n = 6). The results of all the experiments were recorded and data obtained were subjected to statistical analysis (Snedecor and Cochran, 1994) for one-way Analysis of Variance and Duncan’s multiple range tests was conducted to test the significance of difference between means ($p<0.05$).

RESULTS AND DISCUSSION

Compositional analysis

The results of the effect of different cooking methods viz. hot air oven (HO), microwave cooking (MO) and pressure cooking (PC) on proximate analysis of buffalo meat patties with 15% added fat (F1) and buffalo meat patties (5% added fat) incorporated with 3.0 percent Tapioca Starch (F2) are represented in Table 1. It was observed that MO and PC patties had a significantly ($p<0.05$) higher moisture content than the HO cooked buffalo meat patties (F1). It might be due to more cooking period employed for hot air oven cooking i.e. 175±5°C for 15 min. than microwave oven cooking (70 sec) and pressure under steam cooking (121°C for 10 min). The inverse relationship of the moisture content and cooking time was also reported by Pawar et al. (2000). It might be attributed to more cooking losses. The highest fat percentage was recorded for MO cooked product, whereas minimum for pressure cooked products. It could be due to more fat losses during HO and PC methods of cooking. However, the higher fat retention in HO cooking could be attributed to the fact that the patties were kept on a steel plate for cooking in a hot air oven, which led to collection of released fat during cooking in that dish and subsequently frying of the patties in the released fat whilst, this was lost during steam cooking.

Table 1. Effect of different cooking methods on the proximate composition of buffalo meat patties with different fat levels (Mean±SE)*

Parameters	Method of cooking					
	F1 (15% added fat)			F2 (5% added fat)		
	HO	MO	PC	HO	MO	PC
Moisture (%)	56.15±1.52 [d]	60.91±1.12 [c]	59.36±0.92 [c]	65.97±0.42 [b]	67.11±0.96 [a]	66.45±0.32 [ab]
Fat (%)	17.66±0.25 [b]	18.93±0.55 [a]	16.85±0.18 [c]	8.31±0.23 [e]	9.07±0.17 [d]	7.52±0.44 [f]
Protein (%)	17.56±0.23 [a]	16.61±0.35 [b]	17.71±0.40 [a]	18.07±0.39 [a]	16.85±0.54 [b]	18.09±0.44 [a]
M:P ratio	3.19±0.04 [d]	3.67±0.05 [b]	3.35±0.04 [c]	3.65±0.06 [b]	3.92±0.03 [a]	3.67±0.04 [b]
K calories/100 g	241.18	248.81	234.49	167.07	169.03	163.64
K calories/patty	155.05	163.84	134.36	112.36	115.27	110.94

HO = Hot air oven cooking; MO = Microwave oven cooking; PC = Pressure cooking.

* Mean±SE with different superscripts in a row differs significantly. n = 6 for each treatment.

Table 2. Effect of different cooking methods on the processing characteristics of buffalo meat patties with different fat levels (Mean±SE)*

Parameters	Method of cooking					
	F1 (15% added fat)			F2 (5% added fat)		
	HO	MO	PC	HO	MO	PC
Cooking yield (%)	85.72±0.95 c	87.80±0.79 b	86.39±1.12 bc	89.67±0.47 a	90.94±0.64 a	90.39±0.58 a
Cooking loss (%)	14.09±0.86 a	12.20±1.19 b	13.61±1.12 ab	10.33±0.47 c	9.06±0.64 d	9.61±0.58 d
Decrease in diameter (%)	10.76±0.07 d	12.30±0.08 b	13.76±0.08a	6.92±0.03 f	9.52±0.05 e	11.91±0.08 c
Gain in height (%)	13.26±0.47 e	19.86±0.45 d	14.19±0.50 e	31.04±0.27 b	34.02±0.45 a	25.16±0.30 c
Shrinkage (%)	6.67±0.05 b	6.82±0.11 b	9.00±0.06 a	0.45±0.02 d	0.48±0.04 d	5.59±0.10 c
Moisture retention (%)	48.13±0.78 c	53.48±0.92 d	51.28±0.96 e	59.16±0.91c	61.03±0.56 a	60.06±0.82 ab

HO = Hot air oven cooking; MO = Microwave oven cooking; PC = Pressure cooking.

* Mean±SE with different superscripts in a row differs significantly. n = 6 for each treatment.

Hence, the significantly ($p<0.05$) higher fat percentage was recorded for HO cooked patties than PC patties. Raj et al. (2005) also reported that fat and moisture contents were higher in microwave cooking, compared to other cooking processes. Similar results were also observed for moisture and fat content of low-fat patties (F2). The maximum moisture and fat contents were recorded for MO cooked products i.e. 67.11±0.96 and 9.07±0.17 percent, respectively in group F2. However, it was observed that the total fat content remained well below the prescribed limits (<10% total fat) of low-fat meat products on cooking with different methods under study. It was further observed that the moisture content was significantly higher in low-fat buffalo patties (F2) than F1 irrespective of the type of cooking methods. It might be due to the moisture binding ability of tapioca starch incorporated as fat replacer (Nissar et al., 2009).

The moisture protein ratio (MPR) showed a linear increasing trend from HO, PC and MO, respectively irrespective of fat content in the product. This could be attributed to the relative percent variation in moisture and protein content with respect to cooking methods. Calorie estimates were highest for the MO cooked products and minimum for the PC products due to obvious difference in the fat content in the product (Kumar et al., 2007; Nissar et al., 2009). Moreover, the calorie content of low-fat patties (F2) were reduced by 30-32% than F1 with 15% added fat.

Processing characteristics

The results of the effect of method of cooking on the product determinants are expressed in Table 2. The highest cooking yield was recorded for microwave cooked products. However, the cooking yield was significantly ($p<0.05$) better in low-fat patties, F2 than F1 irrespective of cooking methods. These observations are further strengthened by the results of moisture retentions. Our results are in consonance with the previous studies on low-fat pork patties (Kumar et al., 2007) and low-fat buffalo patties (Nissar et al., 2008; 2009). There were minimum cooking/drip losses and more retention of moisture and fat content in the MO products. Hoda et al. (2002) reported that moisture reduction of MO cooked products was less as compared to HO oven cooked products. The percent decrease in diameter varied significantly ($p<0.05$) with the method of cooking. It was recorded maximum for PC and minimum for HO cooking irrespective of fat content. However, the percent gain in height was highest for MO cooked product. It leads to lower shrinkage percentage for MO product. The highest shrinkage was recorded for PC products. In general, the dimensional parameters were better maintained in low-fat patties (F2) than high-fat buffalo meat patties (F1) irrespective of the cooking methods. It might be attributed to tapioca starch, fat replacer which has better moisture and fat retention properties (Nissar et al., 2009).

Sensory quality

Perusal of Table 3 of the sensory attributes of buffalo meat patties showed that the method of cooking significantly ($p<0.05$) influenced the appearance and colour parameters. The sensory panelists scored maximum for the buffalo patties cooked in hot air oven. However, it was not influenced by fat content in the product. The sensory panelists observed that hot air oven cooked products were bright red in colour and had more appealing appearance and colour. It might be attributed to the fact that there was some frying due to collection of drip fat in the steel plate during cooking as corroborated by Nissar et al. (2009) and Pawar et al. (2000).

The hot air oven cooking method showed a significantly ($p<0.05$) higher flavour scores for both F2 and F1, whereas the microwave cooking recorded the least score. The absence of surface drying and Maillard browning reaction in MO cooking might have resulted in low flavour. (Raj et al., 2005), while Nath et al. (1996) reported no change in flavor scores of patties cooked by conventional and microwave oven methods probably due to the variations in

Table 3. Effect of different cooking methods on the sensory quality of buffalo meat patties (Mean±SE)*

Attributes	Method of cooking					
	F1 (15% added fat)			F2 (5% added fat)		
	HO	MO	PC	HO	MO	PC
Appearance/colour	6.60±0.13 [a]	5.60±0.17 [c]	5.81±0.21 [bc]	6.88±0.14 [a]	5.98±0.19 [b]	6.07±0.14 [b]
Flavour	6.55±0.15 [b]	5.69±0.18 [d]	5.88±0.18 [d]	6.93±0.13 [a]	5.98±0.19 [cd]	6.07±0.14 [c]
Juiciness	6.17±0.17 [b]	5.71±0.17 [c]	5.79±0.10 [c]	6.52±0.18 [a]	6.14±0.12 [b]	6.07±0.13 [b]
Texture	6.29±0.13 [a]	5.79±0.16 [b]	5.50±0.16 [b]	6.50±0.19 [a]	5.86±0.22 [b]	6.12±0.13 [ab]
Overall acceptability	6.29±0.13 [b]	5.67±0.17 [c]	5.71±0.19 [bc]	6.90±0.12 [a]	6.12±0.19 [b]	6.29±0.11 [b]

HO = Hot air oven cooking; MO = Microwave oven cooking; PC = Pressure cooking.
Mean±SE with different superscripts in a row differs significantly n = 21 for each treatment.
Means are scores given by sensory panelists on 8 point descriptive scale where 1: extremely undesirable and 8: extremely desirable.

the formulation. The rapid microwave cooking liberates only one third of the total number of volatiles. Lack of sensory flavour after microwave heating is associated with lack of browning reaction also (Ohlsson and Bengtsson, 2001; Hoda et al., 2002).

The flavour scores of PC patties were non significantly higher than MO cooked patties in both the groups. The juiciness score of the MO and PC patties was comparable to each other, whereas these were significantly ($p<0.05$) lower than the HO cooked patties in both the groups. It might be due to peculiar mouth feel provided by the fat present on the surface, which was attributable to softer touch and consequently better juiciness. Raj et al. (2005) and Pawar et al. (2000) reported that the juiciness of MO cooked patties was found to be the lowest, when compared to the conventional HO cooked patties.

The sensory panelists had awarded significantly ($p<0.05$) higher texture scores to patties cooked in HO than patties cooked in MO and PC for both the groups F1 and F2. This indicated that HO cooking is the suitable method for desirable textural properties of the product. Sharma et al. (2005) also reported that chicken meat patties cooked by microwave oven were hard and have low juiciness and other organoleptic characteristics than convection oven cooked patties. The texture scores of the microwave cooked patties were non-significantly ($p<0.05$) higher than pressure cooked patties. This might be due to the fact that protein gel matrix became unstable as a result of high temperature moist heat. The HO cooked patties were rated the best in terms of overall acceptability of the product. This is consistent with the findings of Raj et al, (2005), Hoda et al. (2002) and Pawar et al. (2000). These authors also concluded that the overall acceptability score of the patties cooked by HO were significantly higher than MO cooked patties. In addition to above discussion, it is worth mentioning here that the sensory scores of low-fat (5% added fat) buffalo meat patties were better or comparable to buffalo patties with 15% added fat. Juiciness and overall acceptability scores were significantly ($p<0.05$) better for F2 than F1 irrespective of cooking methods attributed to better moisture retention by tapioca starch (Nissar et al., 2009).

Microbiological quality

The results revealed that the Standard Plate Count (SPC) of both F1 and F2 cooked by HO and MO were comparable (Table 4). This finding is in accordance with the results of Sharma et al. (2005) who found that the microbial reduction was similar in microwave and convectional cooking. The microbial reduction is more in PC products. It might be due to more penetration of moist heat subsequently killing of more number of microbes during

Table 4. Effect of different cooking methods on the microbiological quality of buffalo meat patties (Mean±SE)*

Cooking method		Standard plate count (log cfu/g)	Psychrotrophic count (log cfu/g)	Coliform count (log cfu/g)
F1 (15% added fat)	HO	1.59±0.23 [a]	0.33±0.09 [a]	ND
	MO	1.67±0.27 [a]	0.27±0.14 [a]	ND
	PC	0.60±0.35 [b]	0.14±0.11 [b]	ND
F2 (5% added fat)	HO	1.59±0.22 [a]	0.52±0.16 [a]	ND
	MO	1.67±0.14 [a]	0.54±0.34 [a]	ND
	PC	0.67±0.35 [b]	0.19±0.12 [b]	ND

HO = Hot air oven cooking; MO =Microwave oven cooking; PC = Pressure cooking; ND = Not detected.
* Mean±SE with different superscripts in a raw differs significantly.

pressure cooking (Jay, 1996).

The pressure cooked high-fat control patties and LFBMP showed a mean SPC of 0.60±0.35 and 0.67±0.35 log cfu/g, respectively which might be due to the fact that high-fat content itself acts as a hurdle for the growth of many microorganisms except lipolytic organisms (Kumar and Sharma, 2004). Counts for the SPC, psychrotrophs and coliforms were well below the levels i.e.$\log_{10}$ 7 cfu/g, $\log_{10}$ 4 cfu/g and $\log_{10}$ 3 cfu/g that could cause microbial spoilage (Jay, 1996).

Conclusions

The moisture, fat retention and cooking yield were better in microwave cooked products, however, the sensory panelists graded higher scores for hot air oven cooked patties than other cooking methods irrespective of fat content in the product. The microbiological quality remained acceptable in all the cooked products, irrespective of cooking methods and fat content.

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