

## Effect of Enrobing and Adding Antioxidants on the Quality of Pork Patties

A. K. Biswas\*, R. C. Keshri and Sunil Kumar<sup>1</sup>

Division of Livestock Products Technology, Indian Veterinary Research Institute, Izatnagar, Bareilly, U.P.-243 122, India

**ABSTRACT :** The effect of applying edible coating and addition of antioxidants (butylated hydroxyanisole (BHA) plus butylated hydroxytoluene (BHT) in a 1:1 ratio) on pork patties were investigated prior to achieve desired physico-chemical, microbiological and sensory qualities. For this, five treatments were conducted as (i) control (neither coated nor antioxidants treated); (ii) coated without antioxidants treated; (iii) coated and antioxidants added in the batter mix only (100 ppm); (iv) coated and antioxidants added in meat mix (100 ppm) only; and (v) coated and antioxidants added both in the batter mix (50 ppm) and the meat mix (50 ppm). Addition of antioxidants both in the batter mix and the meat mix significantly ( $p < 0.05$ ) reduced the microbial loads and thiobarbituric acid (TBA) values. The TBA values significantly ( $p < 0.05$ ) increased up to day 14 and then progressively increased with the advancement of each interval of storage days up to 28 days. Total plate count significantly ( $p < 0.05$ ) increased with the increase in storage days. Coliform and *Staphylococcus aureus* were absent throughout the storage days in all samples. *Staphylococcus aureus* however, were present in the control group at day 14 and in enrobed (coated) patties (without antioxidants treated) at 28th day. Addition of antioxidants to batter mix and meat mix did not substantially enhance bacteriostatic activity. Application of coatings and antioxidants retarded the loss of firmness, flavor, changes in appearance and color, and also other sensory attributes. Control patties were better with respect to microbial quality and TBA values but had poorer sensory quality than coated patties. (*Asian-Aust. J. Anim. Sci.* 2003. Vol 16, No. 9 : 1374-1383)

**Key Words :** Enrobing, Coatings, Edible Coatings, Antioxidants, Pork Patties, Enrobed Pork Patties

### INTRODUCTION

Numerous post-harvest treatments exist to prolong the shelf life of meat and meat products. Packaging of fresh produce under modified atmospheres and application of anti-microbial chemicals are two means of extending shelf life. Recently, enrobing or edible coatings have been used successfully in preserving freshness of food products. By inhibiting water loss and controlling rate of oxygen and carbon dioxide migration, enrobing can retain quality and extend shelf life. Enrobing can also be used to retard the loss of volatile flavor and aroma compounds and retard changes in textural properties. But, the application of enrobing and edible coatings or films on precooked meat products has not been as extensively studied as their applications on fresh and frozen meat products (Gennadios et al., 1997). Alginate-coated precooked, frozen stored pork patties had improved sensory qualities and were more desirable than uncoated control patties (Wanstedt et al., 1981). Studies have shown that coating with starch-alginate, starch-alginate-tocopherol, and starch-alginate- rosemary reduced warmed-over flavor (WOF) effectively in precooked refrigerated pork chops and beef patties (Hergens-Madsen et al., 1995; Ma-Edmonds et al., 1995; Handley et al., 1996). Herald et al. (196) used corn zein films containing butylated hydroxyanisole to reduce WOF in precooked turkey breast and reported that turkey breast

wrapped in corn zein films had less WOF than sample packaged in polyvinylidene chloride (PVDC) plastic wrap. Studies on rosemary extract in meat burgers revealed that it significantly delayed the appearance of rancidity and after 27 days of storage the meat supplemented with the extract (plant antioxidants) did not show any indication of oxidation and maintained low microbial levels (Pszczola, 2002). Formanek et al. (2001) reported that rosemary extract had similar effectiveness to that of BHA/BHT combination of beef patties. Activated lactoferrin, a formulation of lactoferrin, can provide fresh meat with an added level of protection from pathogenic bacteria by preventing microbial attachment to meat surfaces during processing and packaging as well as by inhibiting growth of this bacteria (Pszczola, 2002).

Thus, the present study was conducted with the objective of evaluating the effectiveness of enrobing with bengal gram flour (GF) as a base material and antioxidants on physico-chemical, microbiological and sensory characteristics of pork patties.

### MATERIALS AND METHODS

#### Preparation of batter mix

Three different batter mixes were prepared containing either no added antioxidant, 25 ppm butylated hydroxyanisole (BHA) plus 25 ppm butylated hydroxytoluene (BHT) antioxidants, 50 ppm BHA plus 50 ppm BHT antioxidants for battering the pork patties. For this, bengal gram flour (GF) was obtained from the local market of Bareilly (India) and sieved through a fine mesh (U.S.S. 30 # mesh screen). The formula of batter mix (based

\* Corresponding Author: A. K. Biswas. Tel: +91-581-2300940, E-mail: drashim78@rediffmail.com

<sup>1</sup>Department of LPT, College of Vet. Sci. & A. H., Narendra Dev University of Agriculture and Technology, Faizabad, India

Received November 18, 2002; Accepted May 19, 2003

on final weight) included 28.75% bengal gram flour, 36.5% water (v/w), 25% whole egg liquid (obtained from the local market of Bareilly, India), 0.75% carboxymethylcellulose (Hi-Media Laboratories Ltd., Mumbai, India, Code No. RM-329), 2.5% skimmed milk powder (Brand: Anikspray Nutricia Pvt. Ltd., New Delhi, India), 1.5% table salt (Brand: Tata chemicals Ltd., Mumbai, India), 0.5% sugar, 1.5% turmeric powder, 1.5% capsicum powder (Brand: Ramdev Food Products, Ltd., Ahemdabad, India) and 1.5% spice mix (containing aniseed, bay leaves, black pepper, capsicum, caraway seeds, cardamom, cinnamon, clove, coriander, cumin, nutmeg and mace).

The batter mixes were prepared by the following procedure: (1) Flour, carboxymethylcellulose (CMC), skimmed milk powder (SMP), table salt, sugar, spice mix, turmeric and capsicum powder were initially combined and mixed well in the conventional manner on a clean dry glass tray. (2) Whole egg liquid (WEL) containing test antioxidants (BHA and BHT) was added, and mixed well to avoid clumping. (3) Water was added slowly with intermittent mixing of batter mix, which was then stirred continuously until assured of complete hydration and desired consistency. (4) The batter was covered properly and chilled until used to batter the patties. (6) Three batches of batter mix were prepared for each treatment.

#### Preparation of meat mix

Three different meat mixes containing either no test antioxidant or containing BHA and BHT as antioxidants, each at a level of 25 ppm, or 50 ppm were formulated for preparation of patties. Meat samples required for the formulation of meat mix were obtained from pig slaughtered as per scientific method (Anish, 2002) in the experimental abattoir of Livestock Products Technology Division, IVRI, Izatnagar, Uttar Pradesh, India. According to requirement, hams or portions of ham (mainly biceps femoris, quadriceps femoris, semitendinosus, semimebrinosus and gluteus femoris muscles) was taken pre-rigor within 1 h post mortem, and hot deboning was done in the laboratory, manually. Skin, external fat and fascia, and other separable connective tissue trimmed-off from boneless ham and stored over night at  $4\pm 1^\circ\text{C}$  in polyethylene pouches for conditioning. Formulation of meat mix contained 70% lean meat, 15% pork back fat from same pigs, 6% water, 4.5% refined wheat flour (obtained from the local market of Bareilly, India), 1.6% table salt (Brand: Tata Chemicals Pvt. Ltd., Mumbai, India) 0.5% sugar, 0.4% sodium tripolyphosphates (obtained from Central Drug House, New Delhi, India), 0.25% dry ginger powder (obtained from Ashok Griha Udyog Kendra Ltd., Kanpur, India), 150 ppm sodium nitrite (obtained from Polypharm Pvt. Ltd., Mumbai, India), 1.75% spice mix (containing aniseed, bay leaves, black peppers, capsicum,

caraway seeds, cardamom, cinnamon, clove, coriander, cumin, nutmeg, mace), and different levels [0, 50 ppm (25 ppm BHA+25 ppm BHT), 100 ppm (50 ppm BHA + 50 ppm BHT)] of antioxidants.

The meat mixes were prepared by the following procedure: (1) Lean meat (6 kg/ batch) samples were cut into 4-5 cm cubes and double minced first with 8 mm plate followed by common grind size of 3 mm plate in a Electrolux mincer, Model-9152, Germany. (2) The minced meat was blended with other ingredients (as mentioned earlier) in a Hobart paddle type mixer (Model No. 50, Germany) for 3 min. (3) The meat mix was taken out and stored at  $4\pm 1^\circ\text{C}$  till used. (4) Three trials (batches) were conducted for each treatment.

#### Preparation of test samples

Three batches of five different patties (i) control (neither enrobed nor antioxidant treated)  $T_1$ ; (ii) enrobed without antioxidants treated  $T_2$ ; (iii) enrobed and antioxidants added in batter mix (50 ppm BHA+50 ppm BHT) only  $T_3$ ; (iv) enrobed and antioxidants added in meat mix (50 ppm BHA +50 ppm BHT) only  $T_4$ ; and (v) enrobed and antioxidants added in batter mix (25 ppm BHA+25 ppm BHT) and meat mix (25 ppm BHA+25 ppm BHT)  $T_5$  were prepared by using the previously processed batter mixes and meat mixes by following way (1) 75 g of meat was portioned and moulded into a round flat shape by using a 90 mm diameter  $\times$  12 mm height glass petri dish. (2) Patties were deep fat fried (DFF) at  $125^\circ\text{C}$  for 7 min in refined sunflower oil (Brand: Sundrop Agro Tech. Food (P) Ltd., Jaipur, India) using a Batjiboi Gannet thermo-controlled deep fat fryer to a final internal temperature of  $82\pm 2^\circ\text{C}$  as measured with a probe thermometer. (3) Patties were turned upside down and again DFF at the same temperature for uniform colour development. (4) Excess oil was drained off and patties were predested by rolling over the heap of flour for a uniform coating. (5) Patties were battered with the appropriate batter mix having temperature of  $25^\circ\text{C}$  by dipping into it, and then allowing excess batter drain off over a few sec for getting average batter pick up 28% on the basis of raw patties (75 g). (6) Patties were DFF a second time at  $150^\circ\text{C}$  for 6 min with turning at 3 min. (7) Patties were drained off excess oil and cooled at room temperature ( $25^\circ\text{C}$ ) before being packed in polypropylene film and stored at refrigeration temperature ( $4\pm 1^\circ\text{C}$ ) for from 0 to 28 days for subsequent measurement of physico-chemical properties, microbiological quality, and sensory characteristics.

The determined parameters included cooking yield, fat content, moisture content, pH, 2-thiobarbituric acid (TBA) value, shear value, microbial count and sensory panel test. All analysis were performed thrice with duplicate for each treatment.

**Cooking yield :** Yields were determined in batches for each treatment by dividing the cooked weight by raw weight and multiplied by hundred.

**Fat content :** The fat content in cooked patties was estimated by solvent extraction method as given in AOAC (1995).

**Measurement of moisture content :** The moisture content (n=6) was determined by oven drying the sample to a constant weight at 100°C for 16 h (AOAC, 1995).

**Determination of pH :** The pH of the sample was determined (Trout et al., 1992) by using a digital (Century, Model: CP-901) pH meter equipped with a combined glass electrode. For this, 10 g of the sample was homogenized with 50 ml distilled water for 1 min using an Ultra Turrex T<sub>25</sub> tissue homogenizer (Janke and Kunkel, IKA, Labortechnik, Germany).

#### **Determination of 2-thiobarbituric acid (TBA) value**

2-thiobarbituric acid value was determined by the method of Witte et al. (1970) with slight modifications. The samples (20 g) were homogenized by using Ultra Turrex T<sub>25</sub> tissue homogenizer (Janke and Kunkel, IKA, Labortechnik, Germany) at high speed for 1 min in the solution containing 20% trichloroacetic acid (50 ml) and distilled water (50 ml). The homogenate was filtered through Schleicher and Schuell ashless filter paper (equivalent to Whatman # 42), Ref. 300210, supplied by E. Merck (India) Limited, Mumbai. 3 ml of TCA extract was mixed with 3 ml of TBA reagent (0.1 g of 2-thiobarbituric acid dissolved in 100 ml of distilled water) in a graduated test tube and placed in a boiling water bath for 35 min after covering the tube with an inverted small glass beaker. The contents in the tubes were cooled under running tap water and absorbance measured using a spectrophotometer (Du-640, Beckman Instrument, San Ramon, CA, USA.). TBA was calculated as mg malonaldehyde/kg of sample by referring to a standard graph.

#### **Measurement of shear force**

The shear force value of the sample was measured following the method of Berry and Stiffler (1981) with slight modification. The pork patties were cut into 1 cm diameter×1 cm thickness at different locations with a sharp blade. The cut pieces were then sheared in a Warner-Bratzler shear press (Model: 81031307, G.R. Elec, Mfg., Co., USA.). Ten observations were recorded for each sample to obtain the value of shear force in kg/cm<sup>2</sup>.

#### **Microbiological analysis**

Samples from the refrigerated stored pork patties were used to determine the total plate count (TPC), psychrotrophic count (PC), coliform count (CC), *Staphylococcus aureus* count (SAC) and yeast and mold count

(YAM) according to the standard methods of APHA (1984). Analysis were performed at each week interval to monitor microbial quality prior to the sensory tests. The pour plate method in duplicate was used for analyzing the samples. Standard plate count agar (Hi-Media Laboratories Pvt. Ltd., Mumbai, India, Code No M091) was used to determine TPC and PC after incubation for 48 h at 35±2°C and 10 d at 4±1°C, respectively. Enumeration of coliforms was done by Violet red bile agar (Hi-Media Laboratories Pvt. Ltd., Mumbai, India, Code No M49), staphylococcus by Baird Parkar Agar (Hi-Media Laboratories Pvt. Ltd., Mumbai, India, Code No 43) and in both the cases, plates were incubated at 35±2°C for 48 h. Yeast and mold were enumerated by Potato dextrose agar (Hi-Media Laboratories Pvt. Ltd., Mumbai, India, Code No M096) after incubation for 5 d at 25°C.

#### **Sensory panel test**

Five different types of patties at a temperature of 35-40°C were assessed per sitting under incandescent light for their appearance and colour, coating adhesion, flavour, juiciness, texture and overall acceptability by a seven member panel of judges consisting of scientists and post graduate students of the Livestock Products Technology Division at the Indian Veterinary Research Institute using an 8 point descriptive hedonic scale. A length of 2-3 cm pieces of patties were offered to the tasters conducting 3 sittings (n=21) at each storage interval of 0, 7, 14, 21 and 28 days (Baker and Scott-Kline, 1988; Keeton, 1983), where 8=extremely desirable and 1=extremely undesirable.

#### **Statistical analysis**

The statistical design of this study was 5 (treatment)×3 (replication) randomized block design and data were analyzed on a window 98 computer using statistical software packages developed by following the procedures of Snedecor and Cochran (1989). All the analysis were conducted in duplicates. There were seven sensory judges for each treatment×replication combination. Data were subjected to one way analysis of variance and means were compared by critical difference test. The storage data were analyzed on the basis of 5 (treatments)×5 (storage days)×3 (replications) with two way analysis of variance. Duncan's Multiple Range test and critical difference were determined at 5% significant level.

## **RESULTS AND DISCUSSION**

#### **Cooking yield**

The results in Table 1 show the cooking yield of pork patties varied from 85.18±0.68 to 87.42±0.31. Enrobed patties exhibited significantly (p<0.05) higher cooking yield might be due to moisture barrier and fat intake properties

**Table 1.** Effect of enrobing and antioxidants on cooking yield and fat content of pork patties

Treatments	Characteristics	
	Cooking yield (%)	Fat content (%)
T <sub>1</sub>	85.18±0.68 <sup>b</sup>	17.54±0.29 <sup>b</sup>
T <sub>2</sub>	87.33±0.23 <sup>a</sup>	20.34±0.27 <sup>a</sup>
T <sub>3</sub>	87.42±0.31 <sup>a</sup>	19.92±0.62 <sup>a</sup>
T <sub>4</sub>	86.66±0.26 <sup>a</sup>	20.61±0.72 <sup>a</sup>
T <sub>5</sub>	87.30±0.27 <sup>a</sup>	20.78±0.14 <sup>a</sup>

<sup>a,b</sup> Means±SE without same case letter within the same column differ significantly at  $p<0.05$ .

T<sub>1</sub>=Control (neither enrobed nor antioxidant treated), T<sub>2</sub>=Enrobed without antioxidant treated, T<sub>3</sub>=Enrobed and antioxidants added in batter mix only, T<sub>4</sub>=Enrobed and antioxidants added in meat mix only, T<sub>5</sub>=Enrobed and antioxidants added both in batter mix and meat mix.

during DFF. Higher cooking yield also related to adhesion of batter mix on patties as good adhesion improved the cooking yield (Hanson and Fletcher, 1963). Furthermore, starch granules present in flours has moisture absorption properties as they swell by taking moisture from batter mix at the time of heating and thereby increased cooking yield (Miller et al., 1973). However, in this study, treated patties (T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>) did not vary in cooking yield.

#### Fat content

Results in this study showed that treated patties had significantly ( $p<0.05$ ) higher fat content (Table 1), which might be due to absorption of oil by enrobing materials as incorporation of egg yolk content in batter mix formulation increase oil absorption. Mohammad et al. (1998) found that incorporation of liquid egg yolk in batter mix make it lipophilic in nature and thereby increased fat contents in enrobed patties.

#### Moisture content

The results of this study showed that treatment means for the overall moisture content of pork patties ranged from 56.75±0.62 to 52.62±0.75 (Table 2) during 28 days of storage period. The moisture content reduced significantly ( $p<0.05$ ) up to day 14 and then non-significantly up to 28th day as the storage days increased. Control patties showed comparatively higher rate of moisture loss (60.41±0.42 vs. 53.19±0.33) than treated samples (T<sub>2</sub>=55.38±0.82 vs. 52.42±0.56; T<sub>3</sub>=56.09±0.34 vs. 52.16±0.18; T<sub>4</sub> 55.87±0.66 vs. 52.53±0.62; T<sub>5</sub> 55.98±0.42 vs. 52.83±0.81) after 28 days of storage at 4°C. The rate of moisture loss in enrobed patties over the 28 days was less because of coating which released comparatively less moisture than uncoated control. The moisture barrier properties of the coating might be due to incorporation of skimmed milk powder (Cunningham, 1989) and carboxymethylcellulose (Luck, 1968) in the batter mix. This result of moisture content in the present study is in agreement with the work of Wu et al. (2000), who reported that uncoated samples exhibited higher relative moisture loss than coated products of 3 days of storage at 4°C. Chinnan (1997) and Chinnan et al. (1997) also reported that incorporation of corn zein (CZ), methylcellulose (MC), carboxymethylcellulose (CMC) and hydroxypropyl methylcellulose (HPMC) in batter mixes reduced moisture loss. However, overall moisture content in enrobed without antioxidant treated (T<sub>2</sub>) and enrobed-antioxidants treated (T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>) samples were similar (Table 2).

#### pH

Results in Table 2 show that pH was significantly ( $p<0.05$ ) higher in T<sub>1</sub> (control) group compared to T<sub>4</sub> and T<sub>5</sub>

**Table 2.** Effect of enrobing and antioxidants on moisture and pH of pork patties during storage

Parameter	Treatment	Storage time (days)					OAD <sup>2</sup>
		0	7	14	21	28	
M <sup>1</sup>	T <sub>1</sub>	60.41±0.42 <sup>aA</sup>	57.88±0.63 <sup>bA</sup>	54.81±0.46 <sup>cA</sup>	53.77±0.19 <sup>dA</sup>	53.19±0.33 <sup>d</sup>	56.01±0.24 <sup>A</sup>
	T <sub>2</sub>	55.38±0.82 <sup>aB</sup>	54.12±0.41 <sup>bB</sup>	53.01±0.57 <sup>cB</sup>	52.19±0.63 <sup>cB</sup>	52.42±0.56 <sup>c</sup>	53.42±0.16 <sup>B</sup>
	T <sub>3</sub>	56.09±0.34 <sup>aB</sup>	54.41±0.22 <sup>bB</sup>	52.94±0.32 <sup>cB</sup>	52.46±0.44 <sup>cB</sup>	52.16±0.18 <sup>c</sup>	53.61±0.58 <sup>B</sup>
	T <sub>4</sub>	55.87±0.66 <sup>aB</sup>	53.97±0.38 <sup>bB</sup>	52.69±0.84 <sup>cB</sup>	52.81±0.11 <sup>cB</sup>	52.53±0.62 <sup>c</sup>	53.57±0.4 <sup>B</sup>
	T <sub>5</sub>	55.98±0.42 <sup>aB</sup>	54.34±0.56 <sup>bB</sup>	52.88±0.21 <sup>cB</sup>	53.08±0.69 <sup>bcB</sup>	52.83±0.81 <sup>c</sup>	53.82±0.36 <sup>B</sup>
	OAT <sup>3</sup>	56.75±0.62 <sup>a</sup>	54.94±0.28 <sup>b</sup>	53.27±0.39 <sup>c</sup>	52.86±0.55 <sup>c</sup>	52.62±0.81 <sup>c</sup>	-
pH	T <sub>1</sub>	6.56±0.05 <sup>a</sup>	6.53±0.04 <sup>a</sup>	6.48±0.05 <sup>ab</sup>	6.47±0.02 <sup>ab</sup>	6.44±0.72 <sup>b</sup>	6.49±0.02 <sup>A</sup>
	T <sub>2</sub>	6.51±0.04 <sup>a</sup>	6.44±0.05 <sup>a</sup>	6.41±0.05 <sup>a</sup>	6.43±0.05 <sup>ab</sup>	6.44±0.02 <sup>b</sup>	6.43±0.02 <sup>AB</sup>
	T <sub>3</sub>	6.45±0.07 <sup>ab</sup>	6.50±0.02 <sup>a</sup>	6.45±0.05 <sup>ab</sup>	6.47±0.01 <sup>ab</sup>	6.36±0.05 <sup>b</sup>	6.46±0.02 <sup>AB</sup>
	T <sub>4</sub>	6.45±0.06 <sup>a</sup>	6.49±0.05 <sup>a</sup>	6.43±0.06 <sup>a</sup>	6.37±0.05 <sup>ab</sup>	6.35±0.06 <sup>b</sup>	6.42±0.03 <sup>B</sup>
	T <sub>5</sub>	6.45±0.07 <sup>a</sup>	6.44±0.07 <sup>a</sup>	6.44±0.07 <sup>a</sup>	6.40±0.02 <sup>ab</sup>	6.37±0.06 <sup>b</sup>	6.42±0.03 <sup>B</sup>
	OAT	6.48±0.02 <sup>a</sup>	6.48±0.02 <sup>a</sup>	6.40±0.02 <sup>ab</sup>	6.43±0.02 <sup>ab</sup>	6.39±0.02 <sup>b</sup>	-

<sup>a,b,c</sup> Means±SE without same case letters within the same row differ significantly at  $p<0.05$ .

<sup>A,B</sup> Means±SE without same case letters within the same column differ significantly at  $p<0.05$ .

<sup>1</sup> Moisture (%). <sup>2</sup> Overall days Mean±SE. <sup>3</sup> Overall treatments Mean±SE.

T<sub>1</sub>=Control (neither enrobed nor antioxidant treated), T<sub>2</sub>=Enrobed without antioxidant treated, T<sub>3</sub>=Enrobed and antioxidants added in batter mix only, T<sub>4</sub>=Enrobed and antioxidants added in meat mix only, T<sub>5</sub>=Enrobed and antioxidants added both in batter mix and meat mix.

**Table 3.** Effect of enrobing and antioxidants on TBA and shear value of pork patties during storage

Parameter	Treatment	Storage time (days)					
		0	7	14	21	28	OAD <sup>3</sup>
TBA <sup>1</sup>	T <sub>1</sub>	0.56±0.03 <sup>a</sup>	0.66±0.01 <sup>cA</sup>	0.64±0.04 <sup>cA</sup>	0.76±0.04 <sup>bb</sup>	0.86±0.05 <sup>aB</sup>	0.67±0.02 <sup>A</sup>
	T <sub>2</sub>	0.60±0.04 <sup>c</sup>	0.75±0.03 <sup>bb</sup>	0.81±0.04 <sup>aB</sup>	0.84±0.04 <sup>aB</sup>	0.83±0.03 <sup>aB</sup>	0.77±0.02 <sup>B</sup>
	T <sub>3</sub>	0.64±0.02 <sup>b</sup>	0.74±0.05 <sup>abB</sup>	0.76±0.03 <sup>aA</sup>	0.80±0.02 <sup>aB</sup>	0.82±0.03 <sup>aB</sup>	0.76±0.01 <sup>B</sup>
	T <sub>4</sub>	0.57±0.03 <sup>b</sup>	0.61±0.06 <sup>bA</sup>	0.83±0.03 <sup>aB</sup>	0.85±0.02 <sup>aB</sup>	0.83±0.02 <sup>aB</sup>	0.74±0.03 <sup>B</sup>
	T <sub>5</sub>	0.60±0.03 <sup>b</sup>	0.73±0.02 <sup>aB</sup>	0.66±0.05 <sup>abA</sup>	0.68±0.05 <sup>abA</sup>	0.76±0.02 <sup>aA</sup>	0.68±0.01 <sup>A</sup>
	OAT <sup>4</sup>	0.59±0.01 <sup>c</sup>	0.69±0.02 <sup>b</sup>	0.74±0.02 <sup>b</sup>	0.79±0.01 <sup>a</sup>	0.80±0.01 <sup>a</sup>	-
WBSV <sup>2</sup>	T <sub>1</sub>	0.34±0.007 <sup>A</sup>	0.34±0.01 <sup>A</sup>	0.32±0.008 <sup>A</sup>	0.32±0.008 <sup>A</sup>	0.31±0.009 <sup>A</sup>	0.33±0.009 <sup>A</sup>
	T <sub>2</sub>	0.25±0.008 <sup>B</sup>	0.24±0.007 <sup>B</sup>	0.25±0.009 <sup>B</sup>	0.23±0.007 <sup>B</sup>	0.22±0.008 <sup>B</sup>	0.24±0.003 <sup>B</sup>
	T <sub>3</sub>	0.25±0.008 <sup>B</sup>	0.23±0.008 <sup>B</sup>	0.24±0.009 <sup>B</sup>	0.24±0.007 <sup>B</sup>	0.23±0.007 <sup>B</sup>	0.23±0.003 <sup>B</sup>
	T <sub>4</sub>	0.23±0.008 <sup>B</sup>	0.23±0.009 <sup>B</sup>	0.24±0.007 <sup>B</sup>	0.22±0.007 <sup>B</sup>	0.23±0.007 <sup>B</sup>	0.23±0.003 <sup>B</sup>
	T <sub>5</sub>	0.24±0.007 <sup>B</sup>	0.24±0.009 <sup>B</sup>	0.24±0.008 <sup>B</sup>	0.23±0.007 <sup>B</sup>	0.23±0.007 <sup>B</sup>	0.23±0.003 <sup>B</sup>
	OAT	0.26±0.005 <sup>a</sup>	0.26±0.005 <sup>a</sup>	0.26±0.005 <sup>a</sup>	0.25±0.05 <sup>ab</sup>	0.24±0.007 <sup>b</sup>	-

<sup>a, b, c</sup> Means±SE without same case letters within the same row differ significantly at  $p < 0.05$ .

<sup>A, B</sup> Means±SE without same case letters within the same column differ significantly at  $p < 0.05$ .

<sup>1</sup> Thiobarbituric acid (mg malonaldehyde/kg of sample). <sup>2</sup> Warner Bratzler shear force value (kg/cm<sup>2</sup>). <sup>3</sup> Overall days Mean±SE.

<sup>4</sup> Overall treatments Mean±SE.

T<sub>1</sub>=Control (neither enrobed nor antioxidant treated), T<sub>2</sub>=Enrobed without antioxidant treated, T<sub>3</sub>=Enrobed and antioxidants added in batter mix only, T<sub>4</sub>=Enrobed and antioxidants added in meat mix only, T<sub>5</sub>=Enrobed and antioxidants added both in batter mix and meat mix.

group and non-significantly higher than T<sub>3</sub> and T<sub>2</sub> group. However, no change in overall pH (Table 2) was observed with the advancement of storage days in all treatments. Significant decreased in pH values were noticed only over 28 days of chilled storage. The decrease in pH values might be due to significant ( $p < 0.05$ ) increases in psychrotrophic and lactobacillus count at the above storage days producing lactic acid by break down of carbohydrates. The result observed in this investigation was supported by the result reported by Incze (1992). Papadima and Bloukas (1999) also reported decrease in pH of traditional Greek sausages during storage condition. The non-significant variation in pH of cooked patties with added BHA/BHT antioxidants has also been observed by McCarthy et al. (2000).

#### TBA value

Enrobed (T<sub>2</sub>) and enrobed and antioxidants treated (T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>) patties had significantly ( $p < 0.05$ ) higher TBA values (Table 3) which might be due to additional oil absorption by enrobing materials than control. The overall TBA values significantly ( $p < 0.05$ ) increased up to 14th day and non-significantly increased from 21st to 28th day. These findings are in the agreement with Jo et al. (1999), who observed an increase in TBA value with an increase in fat content in pork sausage during storage. It could be due to increased lipid oxidation and production of volatile metabolites in the presence of oxygen during aerobic packaging. Among all enrobed and enrobed and antioxidants treated samples, T<sub>5</sub> had comparatively lower TBA values on the day 21 and 28. This might be due to synergistic effect of combination of antioxidants (BHA+BHT) added both in batter mix and meat mix. McCarthy et al. (2001) reported that BHA/BHT had most

beneficial effect in raw meat oxidative stability during refrigeration storage. T<sub>3</sub> and T<sub>4</sub> group of patties also exhibited lower ( $p < 0.05$ ) TBA values on the day 7 and 14, respectively, but were differed non-significantly from control patties.

#### Shear value

Shear values from the Warner Bratzler shear device can be used to identify if meat products contain a high amount of variability in total shear value. Differences in shear values can be used to determine if differences exist in total shear force between meat samples. Results in Table 3 show that enrobed patties had significantly ( $p < 0.05$ ) lower shear force values which might be due to incorporation of flours and absorption of fat and possibly due to reduction in proportion of muscle fibre and unseparable connective tissues present in the formulations. But no interaction was observed between treatment groups and storage days. Significant ( $p < 0.05$ ) decrease in shear force value at 28th day might be due to myofibrillar fragmentations by muscle or microbial enzyme during storage at 4°C.

#### Total plate count (TPC)

Significantly ( $p < 0.05$ ) increasing trends of TPC were observed with the advancement of each interval of storage days compared to control (Table 4). This might be due to increase in handling and addition of various ingredients in batter mix. This statement was supported by Reddy et al. (1990), who reported higher aerobic count after breading and battering of fish finger. But from the day 14 to 28 a significant ( $p < 0.05$ ) decrease in TPC in T<sub>5</sub> sample was due to antimicrobial effect of BHA/BHT antioxidants added both in batter mix and meat mix. Similar finding has been

**Table 4.** Effect of enrobing and antioxidants on total plate count and psychrotrophic count of pork patties during storage

Parameter	Treatment	Storage time (days)					
		0	7	14	21	28	OAD <sup>3</sup>
TPC <sup>1</sup>	T <sub>1</sub>	2.19±0.19 <sup>Cb</sup>	2.24±0.26 <sup>Bb</sup>	2.18±0.25 <sup>Bb</sup>	2.40±0.13 <sup>abB</sup>	2.61±0.18 <sup>AB</sup>	2.32±0.09 <sup>C</sup>
	T <sub>2</sub>	2.04±0.15 <sup>Cd</sup>	2.45±0.10 <sup>Ac</sup>	2.90±0.13 <sup>Ab</sup>	2.92±0.23 <sup>Ab</sup>	3.61±0.07 <sup>Aa</sup>	2.78±0.11 <sup>B</sup>
	T <sub>3</sub>	2.31±0.06 <sup>Bd</sup>	2.76±0.08 <sup>Ac</sup>	2.94±0.17 <sup>Ab</sup>	3.09±0.17 <sup>Ab</sup>	3.66±0.08 <sup>Aa</sup>	2.95±0.10 <sup>AB</sup>
	T <sub>4</sub>	2.52±0.02 <sup>Ac</sup>	2.62±0.06 <sup>Ac</sup>	2.88±0.15 <sup>Ab</sup>	3.20±0.05 <sup>Aa</sup>	3.66±0.05 <sup>Aa</sup>	2.97±0.08 <sup>A</sup>
	T <sub>5</sub>	2.17±0.07 <sup>Cc</sup>	2.60±0.09 <sup>Ab</sup>	2.23±0.14 <sup>Bc</sup>	2.43±0.17 <sup>Bbc</sup>	2.97±0.09 <sup>Ba</sup>	2.48±0.08 <sup>C</sup>
	OAT <sup>4</sup>	2.25±0.06 <sup>d</sup>	2.53±0.07 <sup>c</sup>	2.63±0.10 <sup>c</sup>	2.81±0.09 <sup>b</sup>	3.30±0.09 <sup>a</sup>	-
PC <sup>2</sup>	T <sub>1</sub>	ND <sup>5</sup>	ND	ND	1.69±0.14 <sup>bB</sup>	1.80±0.12 <sup>aC</sup>	1.75±0.09 <sup>C</sup>
	T <sub>2</sub>	ND	ND	1.69±0.16 <sup>c</sup>	1.76±0.16 <sup>bB</sup>	2.22±0.13 <sup>aA</sup>	1.98±0.08 <sup>A</sup>
	T <sub>3</sub>	ND	ND	1.51±0.12 <sup>c</sup>	1.86±0.15 <sup>bA</sup>	2.01±0.06 <sup>AB</sup>	1.76±0.08 <sup>C</sup>
	T <sub>4</sub>	ND	ND	ND	1.70±0.16 <sup>bB</sup>	2.03±0.10 <sup>AB</sup>	1.86±0.10 <sup>B</sup>
	T <sub>5</sub>	ND	ND	ND	1.81±0.07 <sup>Ab</sup>	1.95±0.10 <sup>AB</sup>	1.82±0.10 <sup>B</sup>
	OAT	-	-	1.60±0.07 <sup>c</sup>	1.81±0.07 <sup>b</sup>	2.01±0.05 <sup>a</sup>	-

<sup>a, b, c, d</sup> Means±SE without same case letters within the same row differ significantly at p<0.05.

<sup>A, B, C</sup> Means±SE without same case letters within the same column differ significantly at p<0.05.

<sup>1</sup> Total plate count (log<sub>10</sub> cfu/g of sample). <sup>2</sup> Psychrotrophic count (log<sub>10</sub> cfu/g of sample). <sup>3</sup> Overall days Mean±SE.

<sup>4</sup> Overall treatments Mean±SE. <sup>5</sup> Not detected in plate.

T<sub>1</sub>=Control (neither enrobed nor antioxidant treated), T<sub>2</sub>=Enrobed without antioxidant treated, T<sub>3</sub>=Enrobed and antioxidants added in batter mix only, T<sub>4</sub>=Enrobed and antioxidants added in meat mix only, T<sub>5</sub>=Enrobed and antioxidants added both in batter mix and meat emulsion.

**Table 5.** Effect of enrobing and antioxidants on coliforms\*, *Staphylococcus aureus* and yeast and mold count of pork patties during storage

Parameter	Treatment	Storage time (days)					
		0	7	14	21	28	OAD <sup>3</sup>
SAC <sup>1</sup>	T <sub>1</sub>	ND <sup>5</sup>	ND	1.59±0.05	ND	ND	1.59±0.05
	T <sub>2</sub>	ND	ND	ND	ND	1.37±0.05	1.37±0.05
	T <sub>3</sub>	ND	ND	ND	ND	ND	-
	T <sub>4</sub>	ND	ND	ND	ND	ND	-
	T <sub>5</sub>	ND	ND	ND	ND	ND	-
	OAT <sup>4</sup>	-	-	1.59±0.05	-	1.37±0.05	-
YAM <sup>2</sup>	T <sub>1</sub>	ND	ND	1.59±0.05	ND	ND	1.28±0.06
	T <sub>2</sub>	ND	ND	1.27±0.06	ND	1.37±0.05	1.27±0.6
	T <sub>3</sub>	ND	ND	ND	ND	ND	-
	T <sub>4</sub>	ND	ND	ND	ND	ND	-
	T <sub>5</sub>	ND	ND	ND	ND	ND	-
	OAT	-	-	1.43±0.06	-	1.37±0.05	-

\* Absent in all samples. <sup>1</sup> *Staphylococcus aureus* count (log<sub>10</sub>cfu/g of sample). <sup>2</sup> Yeast and mold count (log<sub>10</sub>cfu/g of sample). <sup>3</sup> Overall days Mean±SE.

<sup>4</sup> Overall treatments Mean±SE. <sup>5</sup> Not detected in plate.

T<sub>1</sub>=Control (neither enrobed nor antioxidant treated), T<sub>2</sub>=Enrobed without antioxidant treated, T<sub>3</sub>=Enrobed and antioxidants added in batter mix only, T<sub>4</sub>=Enrobed and antioxidants added in meat mix only, T<sub>5</sub>=Enrobed and antioxidants added both in batter mix and meat mix.

reported by Gailani and Fung (1984) in ground pork patties. This effect might be due alteration of cell permeability by phenolic antioxidants and also by interaction with cell membrane protein to cause disruption of membrane structure. The overall TPC showed a linear increasing trend at each interval of storage days up to 28th day. Chicken patties stored at refrigeration temperature also showed a linear increase in total plate count (Nath and Mahapatra, 1995).

### Psychrotrophic count (PC)

Table 4 shows that overall PC had a significantly (p<0.05) increasing trends from 14th day to the end of the experiment. No PC was detected in T<sub>1</sub>, T<sub>4</sub> and T<sub>5</sub> groups

from '0' to 14th day and T<sub>2</sub> and T<sub>3</sub> groups up to 7th day due to sufficient heat treatment during cooking which drastically injured and killed the psychrotrophic population in patties (Jay, 1996). PC was more in enrobed patties which might be due to additional handling and incorporation of different ingredients in batter mix. However, T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub> group of samples had lower overall PC compared to T<sub>2</sub> sample at the day 28, which might be due to inhibitory action of BHA/BHT antioxidants in all the three types of treated patties. This is in agreement with Gailiani and Fung (1984), who reported an inhibitory effect of BHA antioxidants of PC in ground pork after 4 weeks of refrigeration storage.

### Coliforms, *Staphylococcus aureus* and yeast and mold count

Coliforms (CC), *Staphylococcus aureus* (SAC) and yeast and mold (YAM) were not detected at any point of time in the present investigation, except that the SAC were detected in control patties at 14th day and in enrobed (T<sub>2</sub>) patties at 28th day only (Table 5). YAM were also detected only in control (T<sub>1</sub>) and enrobed (T<sub>2</sub>) patties at 14th day. It might be due to destruction of bacteria during DFF of patties (above 82±2°C central core temperature) which have the thermal death points of 57°C. Good hygienic condition during preparation of patties could also be one of the reasons for absence of these bacteria. Moreover, use of antioxidants in patty preparation might also have had important role in inhibition of growth of these bacteria. But SAC and YAM infrequently appeared and might be due to post processing contamination.

### Sensory panel test

Table 6 shows significantly (p<0.05) higher appearance and colour scores in enrobed patties (T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>) compared to control, because of golden brown colour imparted by enrobing and frying. But overall appearance and colour scores significantly (p<0.05) decreased at 7th day onwards. Progressive decrease in appearance and colour scores during storage might be due to pigment and lipid oxidation's resulting in non-enzymatic browning. It

could also be due to relative moisture loss (RML) from the surface of coating. Wu et al. (2000) reported similar observation in precooked beef patties stored in natural antioxidants treated coatings and films. However, in this experiment enrobed-antioxidants treated patties (T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>) did not show any significant different in overall appearance and colour scores over 28 days of storage period. Similar report was mentioned by Resurreccion and Reynolds (1990) as no effective colour stability was observed by BHA/BHT antioxidants up to 18 days of storage in frankfurter containing chicken and pork. But treatment T<sub>2</sub> had lower (p<0.05) appearance and colour value than treatment T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub> on the day 21 and this supported the result obtained by McCarthy (2001).

The scores for coating adhesion on patties varied from 6.64±0.11 to 6.37±0.15 (Table 6). The overall coating adhesion was significantly (p<0.05) higher in T<sub>5</sub> sample and lower in T<sub>2</sub> sample. But these scores significantly (p<0.05) decreased with the advancement of storage days. Differences in coating adhesion might be due to thickness of coating, thick coating peeled-off more quickly than thin coating as loss of integrity of coating materials during storage. It could also be due to release of moisture from coating as dryness reduces tension between coating and patties proper. Hanson and Fletcher (1963) reported similar finding in their study on chicken parts. The adhesion difference among different groups of patties might be due to

**Table 6.** Effect of enrobing and antioxidants on Sensory attributes\* (appearance and colour, coating adhesion and flavour) of pork patties during storage

Parameter	Treatment	Storage time (days)					OAD <sup>4</sup>
		0	7	14	21	28	
AC <sup>1</sup>	T <sub>1</sub>	5.81±0.13 <sup>ab</sup>	5.90±0.15 <sup>aC</sup>	5.95±0.11 <sup>ab</sup>	5.78±0.11 <sup>aC</sup>	5.71±0.13 <sup>BB</sup>	5.83±0.05 <sup>B</sup>
	T <sub>2</sub>	7.00±0.07 <sup>aA</sup>	6.71±0.09 <sup>bB</sup>	6.69±0.09 <sup>abc</sup>	6.61±0.09 <sup>cB</sup>	6.61±0.11 <sup>Ac</sup>	6.72±0.04 <sup>A</sup>
	T <sub>3</sub>	7.02±0.02 <sup>aA</sup>	6.93±0.10 <sup>baB</sup>	6.78±0.07 <sup>bA</sup>	6.78±0.07 <sup>bA</sup>	6.65±0.10 <sup>Ac</sup>	6.85±0.04 <sup>A</sup>
	T <sub>4</sub>	7.02±0.07 <sup>aA</sup>	6.90±0.09 <sup>baA</sup>	6.76±0.08 <sup>bA</sup>	6.80±0.08 <sup>bA</sup>	6.67±0.11 <sup>Ac</sup>	6.83±0.04 <sup>A</sup>
	T <sub>5</sub>	7.00±0.07 <sup>aA</sup>	6.88±0.09 <sup>baA</sup>	6.85±0.09 <sup>baA</sup>	6.80±0.09 <sup>baA</sup>	6.73±0.08 <sup>baA</sup>	6.86±0.03 <sup>A</sup>
	OAT <sup>5</sup>	6.77±0.006 <sup>a</sup>	6.65±0.06 <sup>b</sup>	6.56±0.05 <sup>bc</sup>	6.56±0.05 <sup>bc</sup>	6.52±0.06 <sup>c</sup>	-
CA <sup>2</sup>	T <sub>1</sub>	-	-	-	-	-	-
	T <sub>2</sub>	6.62±0.14 <sup>ab</sup>	6.62±0.13 <sup>ab</sup>	6.33±0.12 <sup>bB</sup>	6.19±0.14 <sup>cC</sup>	6.11±0.17 <sup>cC</sup>	6.37±0.15 <sup>C</sup>
	T <sub>3</sub>	6.71±0.12 <sup>ab</sup>	6.54±0.10 <sup>baB</sup>	6.57±0.12 <sup>bA</sup>	6.33±0.14 <sup>Bc</sup>	6.19±0.12 <sup>cB</sup>	6.47±0.12 <sup>B</sup>
	T <sub>4</sub>	6.74±0.11 <sup>ab</sup>	6.52±0.11 <sup>baB</sup>	6.54±0.11 <sup>bA</sup>	6.44±0.11 <sup>Ac</sup>	6.28±0.09 <sup>Bd</sup>	6.50±0.11 <sup>B</sup>
	T <sub>5</sub>	6.92±0.09 <sup>aA</sup>	6.80±0.1 <sup>baA</sup>	6.57±0.11 <sup>bA</sup>	6.52±0.11 <sup>bA</sup>	6.38±0.08 <sup>Ac</sup>	6.64±0.11 <sup>A</sup>
	OAT	6.74±0.05 <sup>a</sup>	6.62±0.11 <sup>b</sup>	6.50±0.12 <sup>b</sup>	6.37±0.12 <sup>b</sup>	6.24±0.11 <sup>c</sup>	-
FL <sup>3</sup>	T <sub>1</sub>	6.11±0.08 <sup>ab</sup>	6.04±0.09 <sup>abC</sup>	6.11±0.10 <sup>aC</sup>	5.88±0.12 <sup>bc</sup>	5.59±0.10 <sup>cC</sup>	5.95±0.05 <sup>C</sup>
	T <sub>2</sub>	6.80±0.08 <sup>aA</sup>	6.57±0.10 <sup>bB</sup>	6.42±0.09 <sup>Bc</sup>	6.45±0.08 <sup>Bc</sup>	6.33±0.12 <sup>dB</sup>	6.52±0.04 <sup>B</sup>
	T <sub>3</sub>	6.81±0.10 <sup>aA</sup>	6.76±0.09 <sup>baA</sup>	6.52±0.09 <sup>baB</sup>	6.71±0.08 <sup>baA</sup>	6.50±0.11 <sup>baA</sup>	6.66±0.04 <sup>A</sup>
	T <sub>4</sub>	6.80±0.10 <sup>aA</sup>	6.76±0.09 <sup>baA</sup>	6.78±0.08 <sup>baA</sup>	6.73±0.10 <sup>baA</sup>	6.67±0.07 <sup>baA</sup>	6.75±0.04 <sup>A</sup>
	T <sub>5</sub>	6.82±0.10 <sup>aA</sup>	6.76±0.08 <sup>baA</sup>	6.83±0.08 <sup>aA</sup>	6.67±0.12 <sup>baA</sup>	6.67±0.07 <sup>baA</sup>	6.75±0.04 <sup>A</sup>
	OAT	6.68±0.05 <sup>a</sup>	6.58±0.05 <sup>ab</sup>	6.53±0.05 <sup>ab</sup>	6.49±0.05 <sup>b</sup>	6.35±0.06 <sup>c</sup>	-

a, b, c, d Means±SE without same case letters within the same row differ significantly at p<0.05. A, B, C Means±SE without same case letters within the same column differ significantly at p<0.05. \* Based on 8-point descriptive scale, where 8=extremely desirable and 1=extremely undesirable.

<sup>1</sup> Appearance and colour. <sup>2</sup> Coating adhesion. <sup>3</sup> Flavour. <sup>4</sup> Overall days Mean±SE. <sup>5</sup> Overall treatments Mean±SE.

T<sub>1</sub>= Control (neither enrobed nor antioxidant treated), T<sub>2</sub>=Enrobed without antioxidant treated, T<sub>3</sub>=Enrobed and antioxidants added in batter mix only, T<sub>4</sub>=Enrobed and antioxidants added in meat mix only, T<sub>5</sub>=Enrobed and antioxidants added both in batter mix and meat mix.

**Table 7.** Effect of enrobing and antioxidants on sensory attributes\* (juiciness, texture and overall acceptability) of pork patties

Parameter	Treatment	Storage time (days)					
		0	7	14	21	28	OAD <sup>4</sup>
JU <sup>1</sup>	T <sub>1</sub>	6.32±0.12 <sup>ab</sup>	6.09±0.10 <sup>bb</sup>	6.14±0.11 <sup>abB</sup>	6.04±0.10 <sup>bb</sup>	5.83±0.13 <sup>Bc</sup>	6.07±0.05 <sup>B</sup>
	T <sub>2</sub>	6.83±0.10 <sup>aA</sup>	6.64±0.08 <sup>bA</sup>	6.50±0.10 <sup>bcA</sup>	6.64±0.08 <sup>bA</sup>	6.40±0.10 <sup>Ac</sup>	6.57±0.04 <sup>A</sup>
	T <sub>3</sub>	6.86±0.10 <sup>aA</sup>	6.64±0.10 <sup>bA</sup>	6.57±0.10 <sup>bA</sup>	6.57±0.01 <sup>bA</sup>	6.42±0.11 <sup>Ac</sup>	6.62±0.05 <sup>A</sup>
	T <sub>4</sub>	6.83±0.10 <sup>aA</sup>	6.71±0.09 <sup>bA</sup>	6.64±0.11 <sup>bA</sup>	6.54±0.13 <sup>Ac</sup>	6.52±0.09 <sup>Ac</sup>	6.70±0.04 <sup>A</sup>
	T <sub>5</sub>	6.95±0.10 <sup>aA</sup>	6.76±0.09 <sup>bA</sup>	6.66±0.10 <sup>bA</sup>	6.62±0.13 <sup>bcA</sup>	6.52±0.09 <sup>Ac</sup>	6.70±0.05 <sup>A</sup>
	OAT <sup>5</sup>	6.74±0.05 <sup>a</sup>	6.57±0.05 <sup>b</sup>	6.50±0.05 <sup>b</sup>	6.44±0.05 <sup>bc</sup>	6.34±0.10 <sup>c</sup>	-
TE <sup>2</sup>	T <sub>1</sub>	6.38±0.11 <sup>ab</sup>	6.19±0.07 <sup>bb</sup>	6.28±0.10 <sup>abB</sup>	6.07±0.04 <sup>bb</sup>	5.83±0.12 <sup>Bc</sup>	6.15±0.04 <sup>B</sup>
	T <sub>2</sub>	6.92±0.11 <sup>aA</sup>	6.76±0.08 <sup>bA</sup>	6.57±0.11 <sup>Ac</sup>	6.57±0.10 <sup>Ac</sup>	6.50±0.09 <sup>Ac</sup>	6.67±0.04 <sup>A</sup>
	T <sub>3</sub>	6.93±0.07 <sup>aA</sup>	6.74±0.08 <sup>bA</sup>	6.69±0.10 <sup>bA</sup>	6.62±0.10 <sup>bcA</sup>	6.50±0.09 <sup>Ac</sup>	6.69±0.04 <sup>A</sup>
	T <sub>4</sub>	6.95±0.09 <sup>aA</sup>	6.80±0.09 <sup>bA</sup>	6.78±0.10 <sup>bA</sup>	6.64±0.12 <sup>bcA</sup>	6.54±0.09 <sup>Ac</sup>	6.74±0.05 <sup>A</sup>
	T <sub>5</sub>	6.97±0.06 <sup>aA</sup>	6.76±0.09 <sup>bA</sup>	6.78±0.09 <sup>bA</sup>	6.64±0.12 <sup>bcA</sup>	6.50±0.10 <sup>Ac</sup>	6.73±0.04 <sup>A</sup>
	OAT	6.83±0.04 <sup>a</sup>	6.65±0.04 <sup>b</sup>	6.62±0.05 <sup>b</sup>	6.50±0.05 <sup>c</sup>	6.37±0.05 <sup>d</sup>	-
OA <sup>3</sup>	T <sub>1</sub>	6.17±0.09 <sup>ab</sup>	6.11±0.07 <sup>abB</sup>	5.90±0.11 <sup>bb</sup>	6.07±0.11 <sup>bc</sup>	5.61±0.13 <sup>C</sup>	5.98±0.05 <sup>C</sup>
	T <sub>2</sub>	6.80±0.07 <sup>aA</sup>	6.73±0.09 <sup>bA</sup>	6.64±0.08 <sup>bA</sup>	6.40±0.07 <sup>Bc</sup>	6.33±0.14 <sup>CB</sup>	6.58±0.05 <sup>B</sup>
	T <sub>3</sub>	6.95±0.08 <sup>aA</sup>	6.76±0.08 <sup>bA</sup>	6.83±0.08 <sup>abA</sup>	6.50±0.47 <sup>Bc</sup>	6.48±0.10 <sup>CB</sup>	6.58±0.05 <sup>B</sup>
	T <sub>4</sub>	6.93±0.09 <sup>aA</sup>	6.85±0.10 <sup>abA</sup>	6.64±0.13 <sup>bA</sup>	6.76±0.11 <sup>bA</sup>	6.54±0.08 <sup>Abc</sup>	6.74±0.05 <sup>A</sup>
	T <sub>5</sub>	6.97±0.08 <sup>aA</sup>	6.61±0.08 <sup>bA</sup>	6.59±0.15 <sup>bA</sup>	6.78±0.11 <sup>bA</sup>	6.71±0.08 <sup>bA</sup>	6.75±0.05 <sup>A</sup>
	OAT	6.77±0.05 <sup>a</sup>	6.61±0.05 <sup>b</sup>	6.52±0.06 <sup>b</sup>	6.50±0.05 <sup>b</sup>	6.34±0.06 <sup>c</sup>	-

<sup>a, b, c, d</sup> Means±SE without same case letters within the same row differ significantly at  $p < 0.05$ . <sup>A, B, C</sup> Means±SE without same case letters within the same column differ significantly at  $p < 0.05$ . \* Based on 8-point descriptive scale, where 8= extremely desirable and 1=extremely undesirable.

<sup>1</sup> Juiciness. <sup>2</sup> Texture. <sup>3</sup> Overall acceptability. <sup>4</sup> Overall days Mean±SE. <sup>5</sup> Overall treatments Mean±SE.

T<sub>1</sub>=Control (neither enrobed nor antioxidant treated), T<sub>2</sub>=Enrobed without antioxidant treated, T<sub>3</sub>= Enrobed and antioxidants added in batter mix only, T<sub>4</sub>=Enrobed and antioxidants added in meat mix only, T<sub>5</sub>=Enrobed and antioxidants added both in batter mix and meat mix.

initial coating adhesion difference occurring at the time of processing.

The flavor scores decreased with the increase in storage days. However, T<sub>5</sub> had significantly ( $p < 0.05$ ) higher overall flavor scores than T<sub>1</sub> < T<sub>2</sub> (Table 6) because incorporation of SMP in the batter mix enhanced flavor development (Cunningham, 1989). It also might be due to incorporation of CMC in batter mix as it preserved important flavor components of some fresh products. (Smith and Stow, 1984; Banks, 1984; 1985; Drake et al., 1987; Nisperos-Carriedo and Baldwin, 1988; Meheriuk and Lau, 1988; Santerre et al., 1989; Nisperos-Carriedo et al., 1990). But gradual and significant ( $p < 0.05$ ) decrease in overall flavor score at 21st day might be due to progressive increase in TBA values in patties leading to diminishing of flavor. In fact, T<sub>2</sub> shows lower flavour score than T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>. However, no rancid flavor was perceived by expert taste panelist up to 28th day of storage. This protection against rancid flavor might be due to joint action of enrobing and antioxidants. Herald et al. (1996) reported that pork chops and beef patties coated with corn zein containing BHA antioxidant had lower off- flavor scores than uncoated samples.

Table 7 shows significantly ( $p < 0.05$ ) higher overall juiciness scores in enrobed patties compared to control. This might be due to higher fat level and less release of moisture from the coating (shown in Table 1). T<sub>2</sub> patties decreased ( $p < 0.05$ ) textural score at 14th day, but same is observed in other patties (T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>) on the day 28.

Higher juiciness scores at high fat level have been reported by several workers (Cross et al., 1980; Keeton, 1983; Berry and Leddy, 1984; Kregel et al., 1986 and Reitmeier and Prusa, 1987). Significantly ( $p < 0.05$ ) lower juiciness scores were observed at 7th day and 28th day due to loss of moisture from patties. A linear decrease in juiciness scores of chicken patties was reported by Rao and Reddy (1997). The result observed in the present study is also in agreement with Wu et al. (2000) in showing that enrobed pork chop and beef patties were more juicy than uncoated control products during refrigeration ( $4 \pm 1^\circ\text{C}$ ) storage.

Control (T<sub>1</sub>) had significantly lower overall textural scores than both enrobed (T<sub>2</sub>) and enrobed-antioxidants treated (T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>) patties. The overall textural scores of T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub> samples were nearly similar. But these scores significantly ( $p < 0.05$ ) decreased with increase in the storage days (Table 7). Higher textural scores in enrobed patties were due to the fact that coated patties lost moisture more slowly than uncoated patties. However, significant decreased in textural scores might also be due to changes in functional properties during storage at  $4^\circ\text{C}$ .

Table 7 shows that enrobed (T<sub>2</sub>) enrobed-antioxidants treated (T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>) patties had significantly ( $p < 0.05$ ) higher overall acceptability scores than control (T<sub>1</sub>). Among all enrobed products, sample T<sub>4</sub> and T<sub>5</sub> had significantly ( $p < 0.05$ ) higher acceptability scores than sample T<sub>2</sub> and T<sub>3</sub> as these were vary on day 21. However, no significant differences were observed in between T<sub>4</sub> and T<sub>5</sub> samples.



The overall acceptability scores significantly ( $p < 0.05$ ) decreased at 7th day onward which might be due to decrease in other sensory attributes namely appearance and colour, coating adhesion, flavor, juiciness and texture. The enrobed and antioxidants treated products had higher overall acceptability scores which might be due to enrobing with antioxidants having some beneficial effect on sensory parameters.

### CONCLUSIONS

For precooked pork patties the addition of antioxidants simultaneously in both batter mix and the meat mix ( $T_5$ ) have some beneficial effect on TBA values, microbial qualities and few sensory parameters relative to adding into batter mix ( $T_3$ ) or pork meat mix ( $T_4$ ) alone. Similarly, treatments  $T_3$  and  $T_4$  have some beneficial effect than other pork patties though no way is better than treatment  $T_5$ . In light of these observations, it can be concluded that enrobing with a batter and antioxidant treatments (antioxidants added in batter mix or meat mix or both in batter mix and meat mix) significantly increased product quality and shelf life, where  $T_5$  product is superior to others.

### ACKNOWLEDGEMENTS

The authors would like to thank the Director of Indian Veterinary Research Institute for financial support during the period of research work.

### REFERENCES

- Antony, A. 2002. Studies on traditional pig slaughter practices on pork production and quality. M.V. Sc. Thesis. Deemed University, IVRI, Izatnagar, India.
- AOAC. 1995. Official Methods of Analysis. 16th edn. Association of Official Analytical Chemists. Washington, DC.
- APHA. 1984. Compendium of Methods for the Microbiological Examination of Foods. 2nd edn. (Ed. M. L. Speck). Anim. Pub. Health Assoc., Washington, DC.
- Baker, R. C. and D. C. Scott-Kline. 1988. Development of high protein coating using egg albumen. *Poult. Sci.* 67:557-564.
- Banks, N. H. 1984. Some effect of TAL prolong coating on ripening bananas. *J. Exper. Bot.* 35(150):127-137.
- Banks, N. H. 1985. Internal atmosphere modification in prolong coated apples. *Acta Hort.* 157:105-107.
- Berry, B. W. and D. M. Stiffler. 1981. Effect of electrical stimulation, boning temperature, formulation and rate of freezing on sensory, cooking, chemical and physical properties of ground beef patties. *J. Food Sci.* 46:1103-1106.
- Berry, B. W. and K. F. Leddy. 1984. Effect of fat level and cooking method on sensory and textural properties of ground beef patties. *J. Food Sci.* 49:870-875.
- Chinnan, M. S. 1997. Edible coatings for deep fat frying of starchy products. *Lebensm-wiss.u. Technol.* 30(7):709-714.
- Chinnan, M. S., V. M. Balasubramanian, P. Malikajunan and R. D. Philips. 1997. The effect of edible film on oil uptake and moisture retention of deep fat fried poultry product. *J. Food Proc. Eng.* 20(11):17-29.
- Cross, H. R., B. W. Berry and L. H. Wells. 1980. Effect of fat levels and source on the chemical, sensory and cooking properties of ground beef patties. *J. Food Sci.* 45:792-793.
- Cunningham, F. E. 1989. Developments in Enrobed Products. In: *Processing of Poultry*. (Ed. G. C. Mead) Elsevier Sci. Pub. Ltd., New York, USA. pp. 325-359.
- Drake, S. R., J. K. Fellman and J. W. Nelson. 1987. Post harvest use of sucrose polyesters for extending the shelf life of stored "Golden Delicious Apples" *J. Food Sci.* 52:685-690.
- Formanek, Z., J. P. Kerry, F. M. Higgins, D. J. Buckley, P. A. Morrissey and J. Farkas. 2001. Addition of synthetic and natural antioxidants to alphatocopheryl acetate supplemented beef patties: 1. Effect of antioxidants and packaging on lipid oxidation. *Meat Sci.* 58:337-341.
- Gailani, M. B. and D. Y. Fung. 1984. Antimicrobial effect of selected antioxidants in laboratory media and in ground pork. *J. Food Prot.* 47(6):428-433.
- Gennadios, A., M. A. Hanna and L. B. Kurth. 1997. Application of edible coatings on meats, poultry and seafoods. A review. *Lebensm-wiss.u. Technol.* 30:337-350.
- Handley, D., M. Ma-Edmonds, F. Hamouz, S. Cuppett, R. Mandigo and M. Schnepf. 1996. Controlling oxidation and warmed-over flavour in precooked pork chops with rosemary oleoresin and edible films. In: *Natural Antioxidants Chemistry, Health Effect, and Application* (Ed. F. Shahidi). Champaign, III: AOCS Press; pp. 311-318.
- Hanson, H. L. and L. R. Fletcher. 1963. Adhesion of coatings of frozen fried chicken. *Food Technol. Champaign.* 17:793-794.
- Herald, T. J., K. A. Hachmeister, S. Huang and J. R. Bowers. 1996. Corn zein packaging materials for cooked turkey. *J. Food Sci.* 61:415-417, 421.
- Hergens-Madsen, M., M. Schnepf, F. Hamouz, C. Weller and S. Roy. 1995. Use of edible films and tocopherols in the control of warmed-over flavour. *J. Anim. Diet. Assoc.* 95:A-41.
- Incze, L. 1992. Raw fermented and dried meat products. *Fleischwirtschaft.* 72:58-62.
- Jay, J. M. 1996. Food preservation with chemicals. In: *Modern Food Microbiology* 4th edn., CBS Publishers and Distributors, New Delhi, pp.
- Jo, C., J. I. Lee and D. U. Ahm. 1999. Lipid oxidation, colour changes and volatiles production in irradiated pork sausages with different fat content and packaging during storage. *Meat Sci.* 51:355-361.
- Keeton, J. I. 1983. Effect of fat and Sodium chloride/ Phosphates levels on the chemical and sensory properties of pork patties. *J. Food Sci.* 48:878-881.
- Kregel, K. K., J. Kenneth, K. J. Prusa and K. V. Hughes. 1986. Cholesterol content and sensory analysis of ground beef as influenced by fat level, heating and storage. *J. Food Sci.* 51: 1162-1165, 1190.
- Luck, E. 1968. 2nd July, U.S. Patent 3, 391:1008.
- Ma-Edmonds, M., F. Hamouz, S. Cuppett, R. Mandigo and M. Schnepf. 1995. Use of rosemary oleoresin and edible films to control warmed-over flavour in precooked beef patties. In: *IFT Annual Meeting Book of Abstracts (1995) June 3-7, Anaheim, Calif, Chicago. III: Institute of Food Technologists,*

- pp. 139, Abstract nr 50-6.
- McCarthy, T. L., J. P. Kerry, J. F. Kerry, P. B. Lynch and D. J. Buckley. 2001. Evaluation of antioxidant potential of natural foods/plant extracts as compared with synthetic antioxidants and vitamin E in raw and cooked pork patties. *Meat Sci.* 57: 45-52.
- Meheriuk, M., and O. L. Lau. 1988. Effect of two polymeric coatings on fruit quality of Bartlett and 'd' Anjou Pears. *J. Amer. Soc. Hort. Sci.* 133(2):224-226.
- Mohamed, S., N. Abd Hamid and A. M. Abdul. 1998. Food components affecting oil absorption and crispness of fried batter. *J. Sci. Food. Agric.* 78(1):39-45.
- Nath, R. L. and C. M. Mahapatra. 1995. Effect of levels of chicken fat on the quality and storage life of chicken patties. *Indian J. Poul. Sci.* 30(1):50-57.
- Nisperos-Carriedo, M. O. and E. A. Baldwin. 1988. Effect of two types of edible films on tomato fruit ripening. *Proc. Florida State Horticulture Soc.* 101:217-220.
- Nisperos-Carriedo, M. O., P. E. Shaw and E. A. Baldwin. 1990. Changes in volatile flavour components of pineapple, orange juice as influenced by the application of lipid and composite coatings. *J. Agric. Food Chem.* 38(6):1382-1387.
- Papadima, S. N. and J. G. Bloukas. 1999. Effect of fat level and storage conditions on quality characteristics of traditional Greek sausages. *Meat Sci.* 51:103-113.
- Pszczola, D. E. 2002. Beefing up innovation for meat and poultry ingredients. *Food Technol.* 56(3):54-66, 79.
- Rao, T. S. and K. P. Reddy. 1997. Influence of binders and refrigerated storage on certain quality characteristics of chicken and duck meat patties. *J. Food Sci. Technol.* 34(5):446-449.
- Reddy, L., T. M. R. Shetty and K. C. Dora. 1990. Utilization of low value fish: 1. Preparation of fish fingers from croaker and perches. *Fishery Tech.* 27(2):133-137.
- Reitmeier, C. A. and K. J. Prusa. 1987. Cholesterol content and sensory analysis by fat level and heating. *J. Food. Sci.* 52:916-918.
- Resurreccion, A. V. A. and A. E. Jr. Reynolds. 1990. Evaluation of natural antioxidants in frankfurters containing chicken and pork. *J. Food Sci.* 55(3):629-654.
- Santerre, C. R., T. F. Leach and J. N. Cash. 1989. The influence of sucrose polyester, semperfresh, on the storage of Michigan grown 'McIntosh' and 'Golden Delicious Apple'. *J. Food Proc. Preserv.* 13:293-305.
- Smith, S. M. and J. R. Stow. 1984. The potential of sucrose ester coating material for improving storage and shelf life qualities of Cox's Orange Pippin Apples. *Ann. Appl. Biol.* 104:383-387.
- Snedecor, G. W. and W. G. Cochran. 1989. *Statistical methods*, 8th edn. Oxford and IBH Pub. Co., New Delhi.
- Trout, E. S., M. C. Hunt, D. E. Johnson, J. R. Claus, C. L. Kastner and D. H. Kropf. 1992. Characteristics in low-fat ground beef containing texture modifying ingredients. *J. Food Sci.* 57(1):19-24.
- Wanstedt, K. G., S. C. Seidman, L. S. Donnelly and N. M. Quenzer. 1981. Sensory attributes of precooked, calcium alginate-coated pork patties. *J. Food Prot.* 44:732-735.
- Witte, V. C., S. F. Krause and M. E. Bailey. 1970. A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. *J. Food Sci.* 35:582-585.
- Wu, Y., J. W. Rhim, C. L. Weller, F. Hamouz, S. Cuppett and M. Schnepf. 2000. Moisture loss and lipid oxidation for precooked beef stored in edible coatings and films. *J. Food Sci.* 65(2):300-304.