RESEARCH ARTICLE

Effect of Different Wrap Films on Physico-Chemical Properties of Tray Packaged Boneless Chicken Chunks Stored at -18±2 °C

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Abstract

The need for the proper and convenient packaging methods of meat like tray packaging is surging in India. This study was designed to evaluate influence of low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), high density polyethylene (HDPE) and polyvinylchloride (PVC) wrap films on various physico-chemical properties (pH, instrumental colour, water activity, TBARS, tyrosine value and extract release volume) of boneless chicken at frozen (-18±2 °C) conditions. About 200 g of deboned chicken was aerobically packed separately in food grade polypropylene trays, heat sealed and studied at 1 month interval for 3 months. In frozen storage deboned chicken had good qualities in the case of all the treatment films for a period of 3 months. Tray packaged chicken sealed with HDPE film had better qualities and chicken sealed with PVC film had better colour (L, a,b) characteristics than that of other films. Thus, it can be concluded that tray packaging of meat sealed with HDPE film can be successfully used under frozen conditions for maintenance of better quality.

Key words: Boneless chicken, Frozen, HDPE, pH, Physic-chemical, Polypropylene tray, Water Activity.

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Introduction

Meat is a highly nutritious food, rich in high-quality protein and essential amino acids with high biological value (Ahmad, 2005; Lawrie and Ledward, 2006; Nohr and Biesalski, 2007). As per World Bank projections, global food demand will rise by 50% and meat demand by 85% in 2030 (Guleria *et al.,* 2015). India's total meat production was projected to be 7.4 million tons for 2016-17, indicating a significant growth (BAH & FS, 2018). Packaging, a crucial part of both processing and marketing, often accounts for 25% of a product's ex-factory cost. The selection of suitable packaging materials for meat, typically focus on the barrier properties, with plastics being widely used. Their moisture and gas barrier properties ensure extended shelf life of the product (Emblem, 2012). Films like LDPE, HDPE and PVC offer varying degrees of protection based on their polymer quality. Inadequate shelf life often leads to consumer dissatisfaction and complaints. Therefore, proper packaging is essential to maintain quality and consumer complaints, especially in fresh meat marketing.

Nowadays, demand for case-ready packaging has grown due to lifestyle changes and a preference for minimally processed foods. During the last few decades, most of the developed countries widely use trays wrapped with shrink films due to its benefits such as good appeal, longer shelf life, better labelling and easier transportation. In India, tray packaging of meat is still developing and requires lots of research to identify the best combination of tray and wrap films. LDPE is the most commonly used film for wrapping purpose due to its easy availability and cost effectiveness, but alternatives like HDPE, LLDPE and PVC provide superior barrier properties and puncture resistance (Han *et al.,* 2005). With the above listed advantages of tray packaging for better life and consumer acceptance, this study was aimed to determine the physico-chemical, sensorial and microbial quality characteristics of deboned chicken in tray packaging using different wrap films, *viz.,* LDPE, LLDPE, HDPE and PVC at frozen temperature (-18°±2°C).

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Materials and Methods

Sources of Materials, Packaging and Storage

The dressed birds were procured from Post Harvest Technology (PHT) Division, ICAR - Central Avian Research Institute, Izatnagar, Bareilly, UP (India). After deboning manually, removing the separable connective tissue and subcutaneous fat, lean meat was collected. Immediately the deboned chicken was packed in food grade polyethylene bags and brought to the laboratory. All the media, chemicals (analytical grade), plastic wares and glass wares for laboratory use were also procured from standard firms (Hi-Media, Sisco Research Laboratories Pvt. Ltd., Tarson, Borosil etc). Food grade polypropylene trays with a dimension of 19x14x3cm (LxWxH) and different food grade flexible films like LDPE, HDPE, LLDPE and PVC were purchased from local market of Bareilly to use as packaging materials.

About 200 g of deboned chicken was aerobically packed in food grade PP trays using LDPE, HDPE, LLDPE and PVC wrap films and heat sealed. The chicken was stored at frozen condition (-18±2°C) and evaluated for physico-chemical, sensorial and microbiological qualities at 1 month interval upto 3 months for comparing the efficacy of different wrap films.

Analyses of Physicochemical Parameters

The pH was determined by the method of Trout *et al.* (1992) by immersing combined glass electrode of digital pH meter (Edge, Hanna, Romania) in pH homogenates. Instrumental colour profile was measured using Hunter Lab (Portable type, 703.471.6870, USA). The instrument was calibrated using black and white tiles provided with the instrument. Hunter 'L' (brightness (100) / lightness (0)), 'a' (redness (+) / greenness (-)) and 'b' (yellowness (+) / blueness (-)) values were recorded directly on a uniform surface of deboned chicken at three different points. Water activity (a_w) was measured with the help of a dew point water activity meter (4TE, Aqualab). The sample was placed in the sample container up to 1/2 to 3/4th level and introduced inside the sample chamber. The water activity was recorded in 'quick mode' and recorded after the beep sound.

The TBARS value was determined by using the distillation method described by Tarladgis *et al.* (1960) using spectrophotometer (10S UV-VIS, Genesys, Thermoscientific) at 538 nm. The O.D. was multiplied by the factor 7.8 to get the TBARS value which was expressed as mg malonaldehyde/kg of sample. The procedure of Strange *et al.* (1977) was followed to determine tyrosine value. The optical density of mixture was measured at 730 nm. Tyrosine value was calculated as mg of tyrosine per 100 g meat sample by referring to a standard graph. The Extract release volume (ERV) was estimated according to the procedure described by Jay (1964) with suitable modifications. The volume of filtrate collected in first 15 min was recorded as ERV of the respective sample.

Statistical Analysis

The study was replicated thrice and in each replication, measurements of all parameters were done in triplicate. Sensory evaluation was performed by a panel of six member judges three times, so total observations being 18 (n=18). The values were presented as mean along with standard error (Mean ± Standard Error). The analysis was carried out using SPSS software (version 20.0) and data were analysed using two-way ANOVA where treatment and storage time as main effects. Statistical significance was identified at the 95% confidence level ($p<0.05$).

Results and Discussion

pH, Water Activity and Instrumental Colour of stored Chicken

There was an increasing trend in the pH values of chicken meat for the first month of storage followed by decreasing trend for 2nd and 3rd month in case of all the packaging materials, except chicken packaged with LLDPE, where pH increased up to 2nd month followed by decrease in 3rd month (Table 1). There was no significant difference among the pH of chicken packaged with different films for the 1st month. In 2nd and 3rd month chicken packaged with PVC film had lowest pH values and chicken packaged with LLDPE had highest pH values. This decrease in pH during storage could be attributed to many reasons, including the enzymatic reactions, to produce acidic metabolites (Sylvestre *et al.*, 2001). The increase in pH during storage could be due to protein breakdown and liberation of protein metabolites, mainly amines due to bacterial activity during storage (Jay, 1964). The predominance of lactic acid bacteria might be a reason for lower pH of PVC packaged chicken. Similar results were reported by Selani *et al.* (2011), *i.e.,* an initial increase followed by gradual decrease in pH of raw chicken meat up to 9th month of frozen storage.

The water activity (a_w) of chicken meat decreased significantly ($p<0.05$) in all four groups throughout the storage period of study. The initial water activity at 0 month was 0.993 which reduced in range of 0.959 to 0.962 at the end of 3rd month of storage (Table 1). The decrease in water activity might be due to the evaporative loss of moisture of products through films. The water activity of chicken packaged with HDPE was significantly ($p<0.05$) higher than chicken packaged with other films throughout the period of storage. This could be attributable to the high moisture barrier property of HDPE. Similarly, reduction in water activity was reported in meat products with the storage period by Turhan *et al.* (2005).

Colour of meat is very important from the consumer point of view. Lightness (L), redness (a) and yellowness (b) of chicken meat showed significant changes during the storage period. L, a and b values decreased with storage time in this frozen study (Table 2). There was no significant difference between lightness (L) of chicken meat packaged with different films up to two months of storage. During the 3rd month, the lightness of PVC packaged chicken was significantly higher than LDPE and LLDPE packaged chicken. Overall basic, redness (a) was highest in PVC packaged meat and lowest in LLDPE packaged meat. During the 2nd month yellowness was significantly ($p<0.05$) higher in PVC packaged than LLDPE packaged chicken. Similarly, Selani *et al.* (2011) reported a significant decrease in redness value in raw chicken at 6th month of frozen storage. Lavieri and Williams (2014) also reported a decrease in yellowness value of ground beef during storage. The L, a and b values might be decreased because of formation of metmyoglobin which imparted brownish discolouration to meat. Pigment oxidation may facilitate lipid oxidation, and free radicals produced during oxidation may oxidize iron atom or denaturate myoglobin molecules, adversely affecting colour of the meat. There was a positive correlation in sensory colour score with instrumental colour. An insignificant change in the colour values of PVC packaged chicken might be attributed to the better gas barrier property of the film.

TBARS, Tyrosine Value and Extract Release Volume (ERV) of Stored Chicken

Thiobarbituric Acid Reacting Substances (TBARS) values of chicken meat in all treatment groups had a significantly ($p<0.05$) increasing trend with increase in frozen storage period (Table 3). It was due to the lipid oxidation and production of volatile metabolites in the presence of oxygen attributed to oxygen permeability of packaging material (Brewer *et al.,* 1992). Similarly, Selani *et al.* (2011) also reported an increasing trend of TBARS value of raw chicken during frozen storage (-18°C), from 0.24 to 1.29 mg malonaldehyde/kg in 0 to 9 months. Chicken meat packaged with HDPE showed the lowest TBARS value throughout the period of storage. This could be due to lower gas transmission rate of HDPE leading to less oxidative changes in the meat

Tyrosine value is an index of degree of autolytic and bacterial proteolysis occurring in the meat. Tyrosine values of chicken meat in all treatment groups had a significantly ($p<0.05$) increasing trend during frozen storage (Table 3). But there was no significant difference among different groups up to 2nd month of storage. Tyrosine value was significantly lower for meat packaged with HDPE and PVC films than that of meat packaged with LLDPE film at the end of 3rd month of storage. Increase in tyrosine value could be attributed to hydrolytic changes in meat by tissue and bacterial enzymes (Strange *et al.,* 1977). Lower tyrosine value of HDPE and PVC packaged chicken might be due to lower microbial growth in meat packaged with HDPE film. Similarly, Sonale *et al.* (2014) reported a significant ($p<0.05$) increase in tyrosine value of quail breast meat from 0.18 mg/g on 0 day to 0.31 mg/g on 60 days of frozen storage.

Table 1: Effect of different wrap films on pH and water activity (aw) of deboned chicken stored at -18±2 °C

Parameter	Treatment (Polyfilms)	Month			
		0	1	2	3
pH	LDPE (n=9)	5.83±0.008c	5.89±0.008d	5.84±0.006bB	5.72±0.008aAB
	HDPE (n=9)	5.83±0.008c	5.90±0.015d	5.82±0.007bB	5.75±0.009aB
	LLDPE n=9)	5.83±0.008b	5.88±0.009c	5.90±0.009cC	5.75±0.013aB
	PVC (n=9)	5.83±0.008c	5.89±0.009d	5.77±0.009bA	5.68±0.011aA
Water activity	LDPE (n=9)	0.993±0.000d	0.981±0.000cB	0.974±0.000bC	0.960±0.000aB
	HDPE (n=9)	0.993±0.000d	0.983±0.000cC	0.970±0.000bC	0.962±0.000aC
	LLDPE n=9)	0.993±0.000d	0.981±0.000cB	0.972±0.000bB	0.960±0.000aB
	PVC (n=9)	0.993±0.000d	0.977±0.000cA	0.970±0.000bA	0.959±0.000aA

N=9 for each treatment. Mean ± SEs with different superscripts within the row (a,b,c) and within the column (A,B,C) differ significantly ($p<0.05$).

Table 2: Effect of different wrap films on colour of chicken meat stored at -18±2°C (Mean ±SE, n=9)

Meat Color	Treatment (Polyfilms)	Month of storage			
		0	1	2	3
Lightness (L)	LDPE	30.45±0.126d	29.34±0.058c	28.24±0.341b	27.27±0.051aA
	HDPE	30.45±0.126c	29.53±0.011b	28.04±0.051a	27.64±0.029aAB
	LLDPE	30.45±0.126d	29.30±0.063c	28.49±0.079b	27.29±0.059aA
	PVC	30.45±0.126c	29.65±0.073b	28.40±0.202a	28.17±0.060aB
Redness (a)	LDPE	8.91±0.057c	8.65±0.010bA	8.46±0.076bAB	8.04±0.013aAB
	HDPE	8.91±0.057c	8.87±0.016cB	8.51±0.011bB	8.20±0.012aBC
	LLDPE	8.91±0.057d	8.65±0.017cA	8.28±0.009bA	7.92±0.064aA
	PVC	8.91±0.057c	8.75±0.038cAB	8.52±0.043bB	8.29±0.027aC
Yellowness (b)	LDPE	11.86±0.047d	11.54±0.045cAB	11.28±0.021bA	10.92±0.017aAB
	HDPE	11.86±0.047d	11.52±0.008cAB	11.24±0.022bA	11.04±0.054aB
	LLDPE	11.86±0.047d	22.57±11.085cA	11.20±0.048bA	10.78±0.037aA
	PVC	11.86±0.047c	11.68±0.031bcB	11.52±0.025bB	10.88±0.013aAB

Mean ± SEs with different superscripts within the row (a,b,c) and within the column (A,B,C) differ significantly for a trait ($p<0.05$).

Table 3: Effect of different wrap films on TBARS value, Tyrosine value and Extract release volume of chicken meat stored at -18±2°C (Mean ±SE, n=9)

Parameter	Treatment (Polyfilms)	Month of storage			
		0	1	2	3
TBARS value (mg malonaldehyde/kg)	LDPE	0.31±0.009a	0.63±0.012bB	0.83±0.011cB	1.12±0.016dB
	HDPE	0.31±0.009a	0.56±0.010bA	0.69±0.010cA	0.88±0.010dA
	LLDPE	0.31±0.009a	0.64±0.012bB	0.86±0.014cB	1.28±0.016dC
	PVC	0.31±0.009a	0.62±0.008bB	0.93±0.009cC	1.15±0.011dB
Tyrosine value I(mg/g)	LDPE	0.23±0.010a	0.27±0.007b	0.31±0.009c	0.38±0.005dAB
	HDPE	0.23±0.010a	0.27±0.006b	0.29±0.008b	0.35±0.006cA
	LLDPE	0.23±0.010a	0.27±0.009b	0.32±0.006c	0.41±0.005dB
	PVC	0.23±0.010a	0.27±0.006b	0.31±0.006c	0.36±0.004dA
Extract release volume (mL)	LDPE	30.67±0.577c	24.78±0.465bAB	22.67±0.527abAB	20.56±0.626aAB
	HDPE	30.67±0.577c	26.78±0.572bB	24.22±0.465abB	22.11±0.512aB
	LLDPE	30.67±0.577c	24.44±0.530bAB	21.67±0.500aAB	19.44±0.377aA
	PVC	30.67±0.577c	23.78±0.465bA	21.44±0.503abA	20.22±0.521aAB

Mean ± SEs with different superscripts within the row (a,b,c) and within the column (A,B,C) differ significantly for a trait ($p<0.05$).

Extract release volume (ERV) showed significantly ($p<0.05$) decreasing trend during entire storage, which might be due to hydrolysis of proteins caused by enzymatic and bacterial action. But there was no significant difference among different groups throughout the period of frozen storage (Table 3). Sonale *et al*. (2014) also reported a significant decrease in ERV of quail breast meat from 28.33 mL in fresh meat to 17.33 mL after 60 days of frozen storage.

Conclusion

Deboned chicken had maintained good quality attributes in case of all the treatment films under frozen condition (-18±2°C) for a period of 3 months. Tray packaged chicken sealed with HDPE films showed better quality than that of LDPE, LLDPE and PVC films and chicken sealed with PVC film had shown better instrumental colour (L, a, b) characteristics than that of other films. HDPE wrapping film was found to be more advantageous in preserving the quality characteristics of deboned chicken under frozen storage.

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