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## Full Length Research Article

# EXTENSION OF SHELF LIFE OF CHICKEN MEAT BALL BY ADOPTING COMBINATION OF PACKAGING TECHNIQUE AND STORAGE TEMPERATURE

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**ABSTRACT**

A study was conducted to appraise the shelf life of chicken meatball packed in PET/Poly and laminate of metalized PET/Poly with polyethylene pouches under aerobic and vacuum packaging and kept in refrigerator (4±1° C) and freezer (-18±1° C). The samples were analyzed for pH, Thiobarbituric Acid (TBA) Value, Tyrosine value, Total Plate Count (TPC), Total Psychrophilic Count (TPSC), Yeast and Mould Count (YMC), colour, flavour and tenderness. pH, TBA value, Tyrosine value, TPC, TPSC and YMC of the samples increased with the storage period whereas colour, flavour and tenderness decreased throughout the storage period. Irrespective of the packaging material, chicken meatballs were acceptable upto 14th and 21st day of refrigerated storage in aerobic and vacuum packaging respectively. In the freezer storage, the shelf life of the meatballs was 40 days in aerobic packaging and 80 days in vacuum packaging.



## INTRODUCTION

As we all know that meat is a perishable product, it gets spoiled very soon if it is left uncovered and unprocessed in the ambient temperature. Meat can only be stored for future use through proper processing, packaging and storage. Though at present, processing of meat is very little in India, but rapid urbanization and changing life style demand ready to eat and convenient meat products. Chicken meatball is a very good ready to eat meat product which can be stored for a considerable time if it is packed and stored properly. The cause of product deterioration is microbial spoilage, moisture loss, colour change and oxidative rancidity etc. Thus the objective of the study was to evolve the best combination of packaging material, packaging method and storage temperature to preserve the product quality and to determine the shelf life of the meatball under frozen and refrigerated storage.

## MATERIALS AND METHODS

### Source of materials

Spent hens of 2 to 2.5 kg body weight from the same source and age group were slaughtered by modified kosher method and then chilled for 6 hours. Meat of these birds was used for the preparation of meatballs. In the present study six trials were conducted.

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### Chicken meatball preparation

The dressed birds were deboned and excess fat, tendon etc were removed from the meat. Meat was weighed, cut into small chunks and minced. The minced meat was then chopped in a bowl chopper. Following ingredients were used for preparation of emulsion: Meat- 68.5%, fat-5.5%, salt-1.5%, MSG-0.05%, $NaNo_3$- 0.01%, $NaNo_2$-0.01%, sugar-1%, spice mix-3.3%, condiments-8%, soy protein-3.3%, whole egg-1.3%, baking powder-0.03%, ice cubes-5.5% and curd-2.0%. Small balls (approximately 20g) were prepared from the emulsion and deep fried till the desired brown colour appeared. Freshly prepared product was analyzed for different parameters and considered as control for the experiment. Rest portion of the product was packed and kept for subsequent storage study.

### Packaging

For storage study, 100 g of meatballs was packaged for a single subsequent trial. Two types of packaging materials viz. i. polyethylene terepthalate/ low density polyethylene (PET/ Poly) of 150 gauges and ii. laminate of metalized (aluminium) PET and low density polyethylene of 200 gauges were used in this experiment. Each pouch was of 12 X 18 cm in size. Two different methods of packaging i.e., aerobic and vacuum packaging were done.

### Storage

Four pouches of each packaging material under two different methods of packaging i.e. a total of 16 pouches of meatball were stored for studies on 7th, 14th, 21st and 28th day of refrigerated storage (4±1° C). Again, a total of 20 pouches from both types of packaging materials and methods were kept in the freezer (-18 ±1° C) for subsequent analysis on 20th, 40th, 60th, 80th and 100th day of frozen storage.

### Analysis

Samples were analyzed for pH, Thiobarbituric Acid (TBA) value, tyrosine value, microbial parameters and sensory qualities. pH of the meatballs was analyzed as per method described by Trout (1992). TBA and Tyrosine Value were determined by following the method of Tarladgis *et al*. (1960) and Strange *et al*. (1977) respectively. Total Plate Count (TPC), Total Psychrophilic Count (TPSC) and Yeast and Mould Count (YMC) were determined by the methods described by APHA (1984). Colour, flavour and tenderness of meatballs were evaluated by a panel of six trained members using 9 point hedonic scale (Keeton, 1983) where 9 is extremely desirable and 1 is extremely poor. The data were analyzed by statistical method using General Linear Model of SPSS software package developed as per the procedure of Snedecor and Cochran (1994) and means were compared by using Duncan's Multiple Range test (Duncan, 1955).

## RESULTS AND DISCUSSION

### pH

The pH of the meatballs showed a marginal reduction on 7th day followed by an increment on the subsequent day of refrigerated storage (Table 1). The pH in freezer storage decreased insignificantly upto 20th and 40th day of storage in case of aerobic and vacuum packaging respectively and then increased upto the end of the storage period (Table 2). The reduction in pH might be due to the production of acid from the fermentation of carbohydrates of meat, binders and spices by psychrophilic bacteria (Papadima and Bloukas, 1999) and the consequent increment of pH might be due to the liberation of alkaline metabolites from the action of bacteria. The rate of increment in pH was slower in the freezer temperature than that in the refrigerator. This might be due to the advantageous effect of the freezer temperature in arresting the microbial activity to a greater extent. In comparison to aerobic packaging, pH of the vacuum packaged samples increased at slower rate because vacuum hinders the growth of microbes for a longer period (Kim *et al.,* 1996).

### TBA value

Table 1 and 2 showed that TBA value of meatballs increased significantly ($p<0.01$) during refrigerated and frozen storage in case of both the packaging methods and materials. This increment of TBA value was due to oxidation of unsaturated fatty acids of the meatballs during storage (Patterson *et al.* ,2004). The rate of increment in TBA value of samples in freezer storage was slower irrespective of materials and methods of packaging. This might be due to retardation in the rate of oxidation of fat in lower temperature (Panda, 1991). The laminate pouches showed a lower TBA value in both the storage temperatures because of lower water vapour transmission rate (WVTR) and oxygen transmission rate (OTR) of laminates (Dushyanthan *et al.* ,2000). TBA value of the samples increased at a slower rate under vacuum packaging. Absence of oxygen under vacuum packaging resulted in a delayed oxidation of fat and stabilized the packaged items (Nam *et al.,* 2002). In the present study, the TBA value of the stored meatballs exceeded the minimum threshold value for rancidity i.e. 0.5-1.0mg malonaldehyde/kg (Tarladgis *et al.*,1960) in 21 days and in 28 days of refrigerated storage in case of aerobic and vacuum packaging respectively. In the frozen storage, the corresponding days are 60 days in aerobic packaging and 100 days in vacuum packaging. Therefore, the samples were not analyzed for TBA value after these days. Chicken-meatballs were acceptable in terms of TBA value up to 14 and 21 days in case of aerobic and vacuum packaging respectively in refrigerator and up to 40 and 80 days in case of aerobic and vacuum packaging in freezer respectively.

### Tyrosine Value

Table 3 and 4 showed that tyrosine value of meatballs increased significantly ($p<0.01$) during refrigerated and frozen storage in both the pouches under aerobic and vacuum condition. Increment in the tyrosine value during storage was due to proteolysis in meat by increased bacterial population (Eyas, 2001). Bacteria usually produce proteolytic enzymes in the late logarithmic phase of growth and microorganisms increased in number during storage of the products. It is also evident that tyrosine value increased at a slower rate in the freezer than that in the refrigerator as freezer temperature retarded the microbial growth rate, a major cause of proteolysis, to a greater extent. The samples under vacuum showed a lower tyrosine value than those in aerobic pouches. This might be due to the reduced level of proteolysis under vacuum packaging because anaerobic condition inside the pouches created by vacuum packaging slows down the rate of microbial growth (Dushyanthan *et al.,* 2000). The lower tyrosine value in laminates might be due to lower WVTR and OTR of the pouches.

### TPC

TPC of meatballs increased significantly ($p<0.01$) during refrigerated storage irrespective of packaging materials and methods (Table 3). In frozen storage, TPC of the samples did not increase significantly up to 20th and 40th day in case of aerobic and vacuum packaging respectively but then increased significantly ($p<0.01$) up to the end of the storage period (Table 4). During first 20 days of frozen storage, TPC of the samples reduced due to the effect of freezer temperature on the microbes to extend their lag phase however, such reduction was statistically not significant. Microbial growth ceased at about -10°C but most of the bacteria were not destroyed even at the lowest cold storage temperature, so some reduction in numbers might have occurred but this might be ignored (Ranken, 2000). After 20 or 40 days, a significant increment of the microbes occurred due to the adaptability of the microbes to the freezer temperature. This is also true for refrigerated storage. The TPC of the samples during frozen storage increased at slower rate than that in the refrigerated storage. This was due to reduction of the microbial cell and extension of the lag phase of microbial growth caused by cold shock in the freezer storage. Again, the OTR of the packaging material decreased with lowering temperature (Patterson *et al.,* 2004) and as oxygen was very essential for the growth of aerobic microbes, freezer temperature reduced the growth rate of microbes in the samples to a greater extent than that by the refrigerator. The samples under vacuum showed lower TPC of

**Table 1. Mean±SEM value of pH and TBA value of *Chicken Meatball* stored at Refrigeration Temperature (N=6)**

| Parameters | Type of packaging | Type of material | 0 day | 7 days | 14 days | 21 days | 28 days | S/ NS |
|---|---|---|---|---|---|---|---|---|
| pH | Aerobic | PET/Poly | 6.02$^{b}$±0.03 | 5.96$^{b}$±0.06 | 6.12$^{ab}$±0.02 | 6.27$^{a}$±0.03 | ND | * |
| | | Laminate | 6.02$^{b}$±0.03 | 5.97$^{b}$±0.02 | 6.10$^{ab}$±0.08 | 6.23$^{a}$±0.04 | ND | ** |
| | Vacuum | PET/Poly | 6.02$^{bc}$±0.03 | 5.92$^{c}$±0.05 | 6.04$^{bc}$±0.02 | 6.15$^{ab}$±0.07 | 6.31$^{a}$±0.06 | ** |
| | | Laminate | 6.02$^{b}$±0.03 | 5.95$^{b}$±0.02 | 6.02$^{b}$±0.04 | 6.11$^{ab}$±0.04 | 6.25$^{a}$±0.03 | * |
| TBA | Aerobic | PET/Poly | 0.106$^{d}$±0.007 | .212$^{c}$±0.005 | .387$^{b}$±0.005 | 0.526$^{a}$±0.006 | ND | ** |
| | | Laminate | 0.106$^{d}$±0.007 | .203$^{c}$±0.004 | .370$^{b}$±0.007 | 0.515$^{a}$±0.004 | ND | ** |
| | Vacuum | PET/Poly | 0.106$^{e}$±0.007 | .220$^{d}$±0.007 | .310$^{c}$±0.006 | 0.415$^{b}$±0.004 | 0.547$^{a}$±0.004 | ** |
| | | Laminate | 0.106$^{e}$±0.007 | .211$^{d}$±0.006 | .312$^{c}$±0.005 | 0.409$^{b}$±0.005 | 0.531$^{a}$±0.004 | ** |

Means bearing different superscripts differ significantly
ND= Not done. S= Significant NS= Non-significant *=P<0.05 **=P<0.01

**Table 2. Mean ± SEM value of pH and TBA value of *Chicken Meatball* stored at Freezer Temperature (N=6)**

| Parameters | Type of packaging | Type of material | 0 day | 20 days | 40 days | 60 days | 80 days | 100 days | S/NS |
|---|---|---|---|---|---|---|---|---|---|
| pH | Aerobic | PET/Poly | 6.02$^{b}$±0.03 | 5.97$^{b}$±0.06 | 6.10$^{b}$±0.02 | 6.30$^{a}$±0.02 | ND | ND | * |
| | | Laminate | 6.02$^{b}$±0.03 | 5.94$^{b}$±0.03 | 6.06$^{b}$±0.07 | 6.24$^{a}$±0.02 | ND | ND | * |
| | Vacuum | PET/Poly | 6.02$^{c}$±0.03 | 5.95$^{c}$±0.04 | 6.03$^{c}$±0.06 | 6.11$^{bc}$±0.04 | 6.21$^{ab}$±0.08 | 6.35$^{a}$±0.02 | * |
| | | Laminate | 6.02$^{c}$±0.03 | 5.92$^{c}$±0.02 | 6.01$^{c}$±0.08 | 6.09$^{bc}$0.01 | 6.18$^{ab}$±0.04 | 6.34$^{a}$±0.05 | * |
| TBA | Aerobic | PET/Poly | 0.106$^{d}$±0.006 | 0.214$^{c}$±0.005 | 0.352$^{b}$±0.003 | 0.521$^{a}$±0.002 | ND | ND | ** |
| | | Laminate | 0.106$^{d}$±0.006 | 0.200$^{c}$±0.004 | 0.324$^{b}$±0.003 | 0.511$^{a}$±0.002 | ND | ND | ** |
| | Vacuum | PET/Poly | 0.106$^{f}$±0.006 | 0.173$^{e}$±0.004 | 0.244$^{d}$±0.002 | 0.341$^{c}$±0.003 | 0.453$^{b}$±0.003 | 0.542$^{a}$±0.002 | ** |
| | | Laminate | 0.106$^{f}$±0.006 | 0.165$^{e}$±0.004 | 0.232$^{d}$±0.004 | 0.338$^{c}$±0.003 | 0.440$^{b}$±0.002 | 0.531$^{a}$±0.003 | ** |

Means bearing different superscripts differ significantly
ND= Not done. S= Significant NS= Non-significant *=P<0.05 **=P<0.01

**Table 3. Mean±SEM value of Tyrosine value and TPC of *Chicken Meatball*s stored at Refrigeration Temperature (N=6)**

| Parameters | Type of packaging | Type of material | 0 day | 7 days | 14 days | 21 days | 28 days | S/ NS |
|---|---|---|---|---|---|---|---|---|
| Tyrosine value | Aerobic | PET/Poly | 0.210$^{d}$±0.005 | 0.325$^{c}$±0.006 | 0.466$^{b}$±0.005 | 0.623$^{a}$±0.004 | ND | ** |
| | | Laminate | 0.210$^{d}$±0.005 | 0.316$^{c}$±0.005 | 0.458$^{b}$±0.004 | 0.611$^{a}$±0.006 | ND | ** |
| | Vacuum | PET/Poly | 0.210$^{e}$±0.005 | 0.295$^{d}$±0.004 | 0.386$^{c}$±0.008 | 0.505$^{b}$±0.006 | 0.645$^{a}$±0.004 | ** |
| | | Laminate | 0.210$^{e}$±0.005 | 0.284$^{d}$±0.008 | 0.372$^{c}$±0.006 | 0.496$^{b}$±0.005 | 0.632$^{a}$±0.005 | ** |
| TPC | Aerobic | PET/Poly | 2.25$^{c}$±0.04 | 2.20$^{c}$±0.05 | 3.09$^{b}$±0.06 | 4.17$^{a}$±0.07 | ND | ND |
| | | Laminate | 2.25$^{c}$±0.04 | 2.22$^{c}$±0.06 | 2.98$^{b}$±0.07 | 4.09$^{a}$±0.05 | ND | ND |
| | Vacuum | PET/Poly | 2.25$^{d}$±0.04 | 2.11$^{d}$±0.06 | 2.36$^{d}$±0.06 | 3.07$^{c}$±0.08 | 3.89$^{b}$±0.04 | 4.63$^{a}$±0.04 |
| | | Laminate | 2.25$^{d}$±0.04 | 2.05$^{d}$±0.06 | 2.26$^{d}$±0.05 | 3.01$^{c}$±0.04 | 3.81$^{b}$±0.06 | 4.56$^{a}$±0.04 |

Means bearing different superscripts differ significantly
ND= Not done. S= Significant NS= Non-significant, **=P<0.01

**Table 4. Mean ± SEM value of Tyrosine value and TPC of *Chicken Meatball*s stored at Freezer Temperature (N=6)**

| Parameters | Type of packaging | Type of material | 0 day | 20 days | 40 days | 60 days | 80 days | 100 days | S/NS |
|---|---|---|---|---|---|---|---|---|---|
| Tyrosine value | Aerobic | PET/Poly | 0.210$^{d}$±0.005 | 0.245$^{c}$±0.006 | 0.413$^{b}$±0.005 | 0.575$^{a}$±0.007 | ND | ND | ** |
| | | Laminate | 0.210$^{d}$±0.005 | 0.236$^{c}$±0.007 | 0.400$^{b}$±0.004 | 0.562$^{a}$±0.008 | ND | ND | ** |
| | Vacuum | PET/Poly | 0.210$^{e}$±0.005 | 0.224$^{e}$±0.006 | 0.313$^{d}$±0.007 | 0.405$^{c}$±0.008 | 0.481$^{b}$±0.005 | 0.580$^{a}$±0.008 | ** |
| | | Laminate | 0.210$^{e}$±0.005 | 0.216$^{e}$±0.004 | 0.311$^{d}$±0.006 | 0.390$^{c}$±0.008 | 0.473$^{b}$±0.006 | 0.571$^{a}$±0.007 | ** |
| TPC | Aerobic | PET/Poly | 2.25$^{c}$±0.04 | 2.20$^{c}$±0.05 | 3.09$^{b}$±0.06 | 4.17$^{a}$±0.07 | ND | ND | ** |
| | | Laminate | 2.25$^{c}$±0.04 | 2.22$^{c}$±0.06 | 2.98$^{b}$±0.07 | 4.09$^{a}$±0.05 | ND | ND | ** |
| | Vacuum | PET/Poly | 2.25$^{d}$±0.04 | 2.11$^{d}$±0.06 | 2.36$^{d}$±0.06 | 3.07$^{c}$±0.08 | 3.89$^{b}$±0.04 | 4.63$^{a}$±0.04 | ** |
| | | Laminate | 2.25$^{d}$±0.04 | 2.05$^{d}$±0.06 | 2.26$^{d}$±0.05 | 3.01$^{c}$±0.04 | 3.81$^{b}$±0.06 | 4.56$^{a}$±0.04 | ** |

Means bearing different superscripts differ significantly
ND= Not done. S= Significant NS= Non-significant, **=P<0.01

**Table 5. Mean ± SEM value of TPSC and YMC of *Chicken Meatball*s stored at Refrigeration Temperature (N=6)**

| Parameters | Type of packaging | Type of material | 0 day | 7 days | 14 days | 21days | 28 days | S/ NS |
|---|---|---|---|---|---|---|---|---|
| TPSC | Aerobic | PET/Poly | 1.60$^{d}$±0.03 | 2.27$^{c}$±0.03 | 2.97$^{b}$±0.03 | 3.78$^{a}$±0.04 | ND | ** |
| | | Laminate | 1.60$^{d}$±0.03 | 2.32$^{c}$±0.04 | 2.92$^{b}$±0.04 | 3.64$^{a}$±0.03 | ND | ** |
| | Vacuum | PET/Poly | 1.60$^{e}$±0.03 | 2.12$^{d}$±0.05 | 2.66$^{c}$±0.05 | 3.21$^{b}$±0.04 | 3.95$^{a}$±0.04 | ** |
| | | Laminate | 1.60$^{e}$±0.03 | 2.10$^{d}$±0.03 | 2.52$^{c}$±0.06 | 3.15$^{b}$±0.02 | 3.83$^{a}$±0.04 | ** |
| YMC | Aerobic | PET/Poly | 0.35$^{d}$±0.03 | 0.68$^{c}$±0.05 | 0.92$^{b}$±0.04 | 1.49$^{a}$±0.05 | ND | ** |
| | | Laminate | 0.35$^{d}$±0.03 | 0.69$^{c}$±0.03 | 0.85$^{b}$±0.02 | 1.42$^{a}$±0.06 | ND | ** |
| | Vacuum | PET/Poly | 0.35$^{e}$±0.03 | 0.59$^{d}$±0.04 | 0.78$^{c}$±0.03 | 0.95$^{b}$±0.05 | 1.45$^{a}$±0.04 | ** |
| | | Laminate | 0.35$^{e}$±0.03 | 0.57$^{d}$±0.03 | 0.72$^{c}$±0.04 | 0.91$^{b}$±0.03 | 1.32$^{a}$±0.04 | ** |

Means bearing different superscripts differ significantly
ND= Not done. S= Significant NS= Non-significant **=P<0.01

**Table 6. Mean ± SEM value of TPSC and YMC of *Chicken Meatballs* stored at Freezer Temperature (N=6)**

| Parameters | Type of packaging | Type of material | 0 day | 20 days | 40 days | 60 days | 80 days | 100 days | S/NS |
|---|---|---|---|---|---|---|---|---|---|
| TPSC | Aerobic | PET/Poly | 1.60$^{c}$±0.03 | 1.81$^{c}$±0.03 | 2.56$^{b}$±0.05 | 3.34$^{a}$±0.04 | ND | ND | ** |
| | | Laminate | 1.60$^{c}$±0.03 | 1.75$^{c}$±0.05 | 2.47$^{b}$±0.04 | 3.30$^{a}$±0.03 | ND | ND | ** |
| | Vacuum | PET/Poly | 1.60$^{d}$±0.03 | 1.46$^{d}$±0.05 | 1.78$^{d}$±0.05 | 2.35$^{c}$±0.06 | 2.98$^{b}$±0.05 | 3.76$^{a}$±0.08 | ** |
| | | Laminate | 1.60$^{d}$±0.03 | 1.39$^{d}$±0.04 | 1.65$^{d}$±0.05 | 2.29$^{c}$±0.03 | 2.91$^{b}$±0.07 | 3.71$^{a}$±0.05 | ** |
| YMC | Aerobic | PET/Poly | 0.35$^{b}$±0.03 | 0.46$^{b}$±0.07 | 0.78$^{ab}$±0.08 | 1.11$^{a}$±0.04 | ND | ND | * |
| | | Laminate | 0.35$^{b}$±0.03 | 0.42$^{b}$±0.04 | 0.73$^{ab}$±0.05 | 1.00$^{a}$±0.07 | ND | ND | * |
| | Vacuum | PET/Poly | 0.35$^{c}$±0.03 | 0.32$^{c}$±0.04 | 0.41$^{bc}$±0.05 | 0.68$^{b}$±0.03 | 0.88$^{ab}$±0.05 | 1.20$^{a}$±0.03 | ** |
| | | Laminate | 0.35$^{c}$±0.03 | 0.29$^{c}$±0.05 | 0.35$^{bc}$±0.07 | 0.62$^{b}$±0.04 | 0.81$^{ab}$±0.05 | 1.09$^{a}$±0.07 | ** |

Means bearing different superscripts differ significantly
ND= Not done. S= Significant NS= Non-significant **=P<0.01 *=P<0.05

**Table 7. Mean ± SEM value of colour and flavour of Chicken Meatballs stored at Refrigeration Temperature (N=6)**

| Parameters | Type of packaging | Type of material | 0day | 7days | 14days | 21days | 28days | S/ NS |
|---|---|---|---|---|---|---|---|---|
| Colour | Aerobic | PET/Poly | 7.50$^{a}$±0.22 | 6.67$^{ab}$±0.33 | 5.83$^{b}$±0.17 | 5.00$^{c}$±0.25 | ND | ** |
| | | Laminate | 7.50$^{a}$±0.22 | 6.83$^{ab}$ ±0.33 | 6.00$^{b}$±0.26 | 5.12$^{c}$ ±0.23 | ND | ** |
| | Vacuum | PET/Poly | 7.50$^{a}$±0.22 | 7.33$^{a}$±0.24 | 6.67$^{ab}$ 0.22 | 5.83$^{bc}$0.37 | 5.00$^{c}$±0.20 | ** |
| | | Laminate | 7.50$^{a}$±0.22 | 7.33$^{ab}$± 0.24 | 6.83$^{ab}$±0.33 | 6.00$^{bc}$±0.26 | 5.17$^{c}$±0.17 | ** |
| Flavour | Aerobic | PET/Poly | 7.67$^{a}$±0.21 | 6.50$^{b}$±0.33 | 5.20$^{c}$±0.19 | 4.00$^{d}$±0.21 | ND | ** |
| | | Laminate | 7.67$^{a}$±0.21 | 6.60$^{b}$±0.33 | 5.33$^{c}$±0.33 | 4.00$^{d}$±0.30 | ND | ** |
| | Vacuum | PET/Poly | 7.67$^{a}$±0.21 | 7.17$^{ab}$±0.41 | 6.50$^{bc}$±0.17 | 5.67$^{c}$±0.21 | 4.12$^{d}$±0.23 | ** |
| | | Laminate | 7.67$^{a}$±0.21 | 7.20$^{ab}$±0.22 | 6.67$^{bc}$±0.26 | 5.80$^{c}$±0.37 | 4.20$^{d}$±0.19 | ** |

*Means bearing different superscripts differ significantly*
ND= Not done. S= Significant NS= Non-significant, **=P<0.01

**Table 8. Mean ± SEM value of colour and flavour of Chicken Meatballs stored at Freezer Temperature (N=6)**

| Parameters | Type of packaging | Type of material | 0 day | 20 days | 40 days | 60 days | 80 days | 100 days | S/NS |
|---|---|---|---|---|---|---|---|---|---|
| Colour | Aerobic | PET/Poly | 7.50$^{a}$±0.22 | 7.00$^{a}$±0.26 | 6.33$^{b}$±0.33 | 5.83$^{c}$±0.37 | ND | ND | ** |
| | | Laminate | 7.50$^{a}$±0.22 | 7.00$^{a}$±0.26 | 6.33$^{b}$±0.21 | 6.00$^{b}$±0.26 | ND | ND | ** |
| | Vacuum | PET/Poly | 7.50$^{a}$±0.22 | 7.25$^{ab}$±0.33 | 6.60$^{bc}$±0.17 | 6.33$^{cd}$±0.21 | 5.85$^{de}$±0.37 | 5.33$^{e}$ ±0.37 | ** |
| | | Laminate | 7.50$^{a}$±0.22 | 7.20$^{ab}$0.33 | 6.65$^{b}$±0.26 | 6.50$^{bc}$±0.22 | 6.00$^{cd}$±0.26 | 5.50$^{d}$±0.21 | ** |
| Flavour | Aerobic | PET/Poly | 7.67$^{a}$±0.21 | 6.83$^{b}$±0.21 | 5.60$^{c}$±0.37 | 4.15$^{d}$±0.24 | ND | ND | ** |
| | | Laminate | 7.67$^{a}$±0.21 | 6.90$^{b}$±0.26 | 5.83$^{c}$±0.26 | 4.25$^{d}$±0.19 | ND | ND | ** |
| | Vacuum | PET/Poly | 7.67$^{a}$±0.21 | 7.33$^{ab}$±0.33 | 6.83$^{bc}$±0.21 | 6.33$^{c}$±0.33 | 5.33$^{d}$±0.37 | 4.00$^{e}$±0.22 | ** |
| | | Laminate | 7.67$^{a}$±0.21 | 7.33$^{ab}$±0.33 | 7.00$^{bc}$±0.26 | 6.50$^{c}$±0.22 | 5.50$^{d}$±0.21 | 4.10$^{e}$±0.31 | ** |

Means bearing different superscripts differ significantly
ND= Not done. S= Significant NS= Non-significant, **=P<0.01

**Table 9. Mean ± SEM value of tenderness of Chicken Meatballs stored at Refrigeration Temperature (N=6)**

| Parameter | Type of packaging | Type of material | 0day | 7days | 14days | 21days | 28days | S/ NS |
|---|---|---|---|---|---|---|---|---|
| Tenderness | Aerobic | PET/Poly | 7.67$^{a}$±0.21 | 6.80$^{b}$±0.19 | 5.80$^{c}$±0.26 | ND | ND | ** |
| | | Laminate | 7.67$^{a}$±0.21 | 6.83$^{b}$±0.17 | 5.83$^{c}$±0.26 | ND | ND | ** |
| | Vacuum | PET/Poly | 7.67$^{a}$±0.21 | 7.17$^{ab}$±0.26 | 6.60$^{bc}$±0.31 | 5.90$^{c}$±0.27 | ND | ** |
| | | Laminate | 7.67$^{a}$±0.21 | 7.22$^{ab}$±0.26 | 6.72$^{bc}$±0.23 | 6.00$^{c}$±0.30 | ND | ** |

Means bearing different superscripts differ significantly
ND= Not done. S= Significant NS= Non-significant, **=P<0.01

**Table 10. Mean ± SEM value of tenderness of Chicken Meatballs stored at Freezer Temperature (N=6)**

| Parameter | Type of packaging | Type of material | 0 day | 20 days | 40 days | 60 days | 80 days | 100 days | S/NS |
|---|---|---|---|---|---|---|---|---|---|
| Tend erness | Aerobic | PET/Poly | 7.67$^{a}$±0.21 | 6.67$^{b}$±0.33 | 5.40$^{c}$±0.19 | ND | ND | ND | ** |
| | | Laminate | 7.67$^{a}$±0.21 | 6.83$^{b}$±0.17 | 5.52$^{c}$±0.37 | ND | ND | ND | ** |
| | Vacuum | PET/Poly | 7.67$^{a}$±0.21 | 7.50$^{a}$±0.22 | 6.83$^{b}$±0.17 | 6.33$^{b}$±0.21 | 5.50$^{c}$±0.37 | ND | ** |
| | | Laminate | 7.67$^{a}$±0.21 | 7.50$^{a}$±0.22 | 7.00$^{b}$±0.26 | 6.50$^{b}$±0.22 | 5.55$^{c}$±0.37 | ND | ** |

Means bearing different superscripts differ significantly
ND= Not done. S= Significant NS= Non-significant, **=P<0.01

the product than those in aerobic pouches because vacuum packaging arrested the proliferation of the aerobic microorganisms by creating an anaerobic condition inside the pouches. The laminates showed lower TPC in both the storage temperatures. This might be due to lower WVTR and OTR of laminate pouches.

## TPSC

TPSC of the meatballs increased significantly (p<0.01) during refrigerated storage (Table 5). In case of frozen storage, TPSC increased significantly after 20$^{th}$ and 40$^{th}$ day of storage in case of aerobic and vacuum packaging respectively (Table 6). The rate of increment of TPSC of the samples during frozen storage was slower than that in case of the samples during refrigerated storage. The reason of reduction and increase in the TPSC of the samples during storage and the explanation for slower rate of increment of TPSC in the freezer storage were the same as discussed under TPC. The samples under vacuum showed significantly lower TPSC of the product than those in aerobic pouches because growth rate of the aerobic microorganisms were reduced in vacuum packaging due to non-availability of oxygen inside the pouches.

### YMC

YMC of meatballs increased significantly ($p<0.01$) during the refrigerated and freezer storage with the exception of slight insignificant decrease in vacuum packed samples on 20th day of freezer storage (Table 5 and 6). It was evident that the rate of increment of YMC of the samples during refrigerated storage was faster than that in case of frozen storage. This difference in the growth rate of yeasts and moulds in two different storage temperatures was due to the persistence of the lag phase of microbial growth for a longer period caused by the cold shock at freezer temperature. Yeast and moulds grew more slowly under vacuum packaging as the primary needs for thriving and multiplication of the microbes became inadequate in vacuum packs (Valin and Lacourt, 1980).

### Sensory Qualities

During refrigerated and freezer storage, the colour, flavour and tenderness score of the meatballs decreased gradually (Table 7, 8, 9 and 10) signifying the loss of colour, flavour and tenderness to undesirable side. Decrease in the colour, flavour and tenderness scores of the meatball with the advancement of the storage period might be due to moisture loss from the product, increased lipid oxidation and proteolysis of the product (Bhoyar *et al*., 1997). The flavour score of the aerobically packed samples on 21st day of refrigerated storage and on 60th day of frozen storage reached to the level below 4.50 and the products became unacceptable after 14th and 40th day of refrigerated and frozen storage respectively. Vacuum packed samples scored below 4.50 on 28th and 100th day of refrigerated and frozen storage respectively so the meatballs were acceptable in terms of flavour up to 21st day of refrigerated storage and 80th day of frozen storage. The samples were not put for evaluation of tenderness score after 14th and 21st day of refrigerated storage for aerobic and vacuum packaging respectively and 40th and 80th day of frozen storage for aerobic and vacuum packaging respectively owing to the results of flavour scores of the samples denoted as unacceptable on the next day of experiment and as such these samples were not assessed by the panelists for scoring the flavour of the products.

The results also showed that these three sensory qualities of the meatballs could be maintained in a good condition for a longer time in freezer than refrigerator. Better maintenance of sensory qualities in freezer storage might be due to lesser degree of dehydration, slower growth rate of microbes and reduced rate of lipid oxidation than those in the refrigerator. Vacuum packaging secured a higher score in terms of colour, flavour and tenderness of the product than aerobic packaging. Vacuum packaging preserved the sensory qualities better because anaerobic condition inside the pouches under vacuum packaging maneuvered some of the factors (viz. dehydration, proteolysis and rancidity) responsible for causing discolouration, off flavour and toughness of the products (Bhoyar *et al*., 1997). The better sensory scores of the samples in laminate pouches might be due to the higher resistance of the laminate to water vapour and oxygen transmission.

### Conclusion

It can be concluded that the chicken meatball can be stored up to 14 days in aerobic packaging and 21 days in vacuum packaging in the refrigerator. In the freezer storage, the meatballs are acceptable up to 40 and 80 days in aerobic and vacuum, packaging respectively. Laminate pouch is better in preserving the qualities of the meatball. The meatballs can be best stored under vacuum packaging in the freezer.

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