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Evaluation of some packaging materials and treatments on some properties of beef during frozen storage

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The moisture content, pH value, thiobarbituric acid (TBA) value, water holding capacity (WHC), and microbiological examination of beef during frozen storage at times up to six months were determined in order to evaluate different packaging materials and treatments. The samples were packaged in low density polyethylene and laminated polyethylene/nylon bags and then sealed with or without vacuum and compared with no protective packaging (control). The water vapour transmission rates (WVTR) of packaging materials were determined under the storage conditions studied. The WVTR values were not only affected by the packaging materials but also by the thickness of the film.

The results indicated insignificant ($P < 0.05$) loss in the moisture contents for the packaged samples, which means that packaging treatments retarded the moisture losses. However, there were no significant differences between the two packaging treatments (with or without vacuum). The same trend was noticed for the pH values, which were higher in the unpackaged than the packaged samples. At the same time, the differences between the two packaging materials and two different treatments were not significant ($P < 0.05$).

The TBA values for the unpackaged samples were higher than those for the packaged samples and significantly increased during storage ($P < 0.01$), whereas the changes in the TBA values for the other samples were not significantly different ($P < 0.05$). The TBA values for the vacuum treatments were low at all times.

All the samples showed a decline in the WHC values during storage, with the rate of decline for the unpackaged samples (control) being dramatic and lowest for the vacuum treatment. There was a reduction in the total bacterial count for all samples during the first 45 days, but the rate of decrease was much more rapid for the samples packed under vacuum.

INTRODUCTION

In some Middle Eastern, African, and Asian countries, most carcasses are stored unpackaged. The lack of packaging materials and the high cost of equipment are limiting factors in these areas. Furthermore, expensive procedures are not practical (Gokalp, 1978, 1979).

To obtain the optimum shelf-life of fresh red meat, it is necessary to limit microbial contamination (Chandran *et al.*, 1986). Zamora and Zaritzky (1985) reported that microbial spoilage can be delayed by storage of meat at low temperature by effects on the growth rate of the organisms. Since frozen meat is highly susceptible to dehydration as a result of moisture losses and temperature fluctuations, the protection of frozen meat against fluctuations in temperature during storage is important from the standpoint of quality retention. An obvious approach is the use of suitable packaging materials to meet various criteria, such as protection against moisture migration and mechanical damage (Zuritz & Sastry, 1986). The permeation of water vapour through the packaging material has a great deal of influence on the preservation of food quality.

Mathlouthi (1986) reported that a good frozen-food package must withstand low temperatures, provide a barrier to transmission of water vapour, be water resistant, be non-toxic and impart no odour or flavour to the food. Ashby and James (1973) stated that packaging is a well recognized preventive treatment against moisture losses from meat under refrigeration. They also reported that, in order to give maximum protection, the packaging material should be relatively impermeable to moisture, adhere to the product to reduce cavity ice within the package, and be tightly sealed. Spencer and Stadelman (1955) found that polyethylene

was the most efficient wrapping material in decreasing weight losses and retaining general appearance during refrigeration.

A serious problem associated with freezing and storing meat is shrinkage resulting from moisture evaporation, which may by caused by a number of factors. Exposed meat may increase shrinkage, reduce juiciness scores, reduce tenderness ratings, and reduce retail caselife (Miller *et al.*, 1985).

Jaye *et al.* (1962) and Seidman *et al.* (1976) reported that vacuum packaging of meat may prolong the shelf-life of retail cuts compared with those packaged in oxygen-permeable film. Zamora and Zaritzky (1985) found that, when meat is vacuum-packaged and the contaminating flora is exposed to an atmosphere containing high levels of carbon dioxide and a low percentage of oxygen, the growth of aerobic micro-organisms is depressed.

Hiner *et al.* (1951) found that the development of rancidity as a result of lipid oxidation limits the storage life of beef held in the frozen state. Susceptibility to auto-oxidation and the development of oxidative rancidity is important in meat quality attributes, such as off-flavours and off-odours (Gokalp *et al.*, 1983).

The water-holding capacity (WHC) of meat is considered to be solely due to the properties of the microfibrillar proteins, which are principal components of muscle (Ranganayaki *et al.*, 1982). Honikel *et al.* (1981) studied the influence of post-mortem storage of beef at various temperatures on WHC. They found that storage at low temperature influences the water-holding capacity.

The main purpose of this investigation was to investigate the protective effects of two different packaging materials with or without vacuum on the subjective quality characteristics of meat during frozen storage.

MATERIALS AND METHODS

Samples

The beef samples (sirloin region) used in this study were obtained from a local market in el-Minia, Egypt, one hour after slaughter. The sample was trimmed and held at 4°C for 24 hours and then cut into slices 2·0 cm thick (about 150–200 g). The slices were random divided into five groups. One group was left unpackaged (control), while the others were packaged as shown below. All the groups were then frozen and stored for six months.

Packaging materials and treatments

Two different packaging materials were used in this study. The first used commercial low density polyethylene (LDPE) 2 m bags from packaging Concepts and Design, a division of Bader Bag Co., Madison Heights, MN, USA. The second packaging material was 3 mil laminated polyethylene/nylon bags from Cryovac Co., USA (1 mil = 0·001 in.)

The beef slices were packaged individually, and the bags were then sealed. Half of each packaging material was sealed at atmospheric pressure, whereas the other half was vacuum sealed using, a Deni Freshlock vacuum sealer.

Determination of water vapour transmission rate (WVTR)

The water vapour transmission rate (WVTR) of the test packages under frozen conditions was determined as described in the ASTM E-96 method.

Determination of moisture content

To monitor the extent of beef dehydration throughout storage, moisture determination (wet basis) was carried out in triplicate according to the method of the AOAC (1985).

pH measurement

A slurry was prepared by blending the meat (5 g/50 ml distilled water). The pH of this slurry was measured by using the glass-electrode method according to the AOAC method (1975).

Thiobarbituric acid (TBA) value

Frozen packaged and unpackaged beef samples were tested separately in duplicate. TBA-reactive substances were measured using the method of Harold *et al.*, 1981. Colorimetric absorbance at 530 nm was measured using a Spectronic 710 spectrophotometer. Readings were converted to mg malonaldehyde/100 g meat and reported as TBA values (mg TBA/100 g meat)

Determination of water holding capacity (WHC)

The press technique was used to measure the WHC of packaged and unpackaged beef according to the method described by Tsai and Ockerman (1981).

Microbiological test

Total aerobic counts were made on plate count agar (Oxoid) with incubation at 30°C for two days according to the method described in the standard methods of APHA (1985).

Statistical analysis

Data were analysed by analysis of variance (ANOVA) to determine if treatments were significantly different (Gill, 1981).

Table 1. Water vapour transmission rate (WVTR) of two packaging materials under freezing conditions

Packaging material	Condition	WVTR g/m^2 day
2 mil low density polyethylene	Freezer	0·055
3 mil laminated polyethylene/nylon	Freezer	0·036

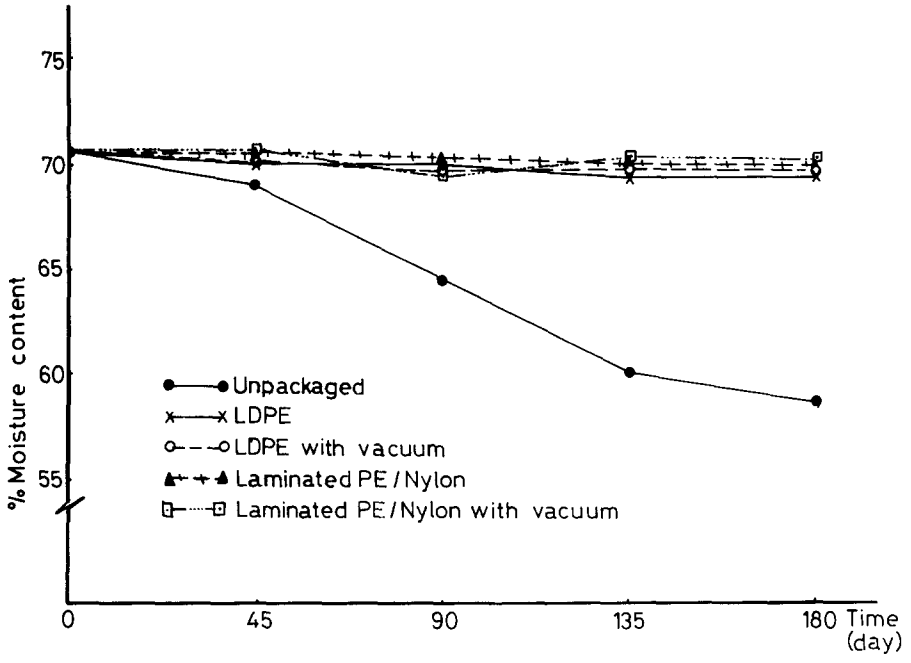

Fig. 1. Temperature–time-of-storage effect on the moisture content of frozen beef with different packaging materials and treatments.

RESULTS AND DISCUSSION

Packaging of food products in polymeric films is a technique designed to prevent moisture losses, to protect against mechanical damage, and to provide better retention of appearance. Proper selection of packaging films can favourably alter some of the undesirable changes taking place during long-term storage and result in an extension of shelf-life and improved quality (Henig & Gilbert, 1975).

Table 1 shows the water vapour transmission rate (WVTR) values for the two packaging materials, low density polyethylene (LDPE) and laminated polyethylene/nylon, under frozen conditions. The laminated film appeared to allow less moisture to escape than the LDPE film under the storage condition. The differences in the WVTR values were caused not only by the packaging materials but also by the thickness of the films.

Figure 1 shows the relationship between the time of storage under frozen conditions and the moisture content for the packaged and unpackaged beef. It is obvious that the moisture losses in the packaged beef were significantly lower ($P < 0{\cdot}55$) than that in the unpackaged (control). The percentage moisture losses for the unpackaged samples were 16·5% at the end of storage (six months). However, for the packaged samples the loss did not exceed 2·0% for the same period. This indicates that packaging in film reduced moisture losses. This may be explained by the effect of packaging materials retarding the moisture vapour permeation from the inside to the outside atmosphere (Ashby & James, 1973; Zuritz & Sastry, 1986). The moisture losses from the beef in different packaging materials (LDPE and laminated PE/nylon) and under different treatments (with or without vacuum) and stored for the same period of time, frozen, were not significantly affected ($P < 0{\cdot}05$).

Figure 2 clearly illustrates the effect of packaging materials, packaging treatments, and time of storage on the pH changes in frozen beef. The data demonstrate

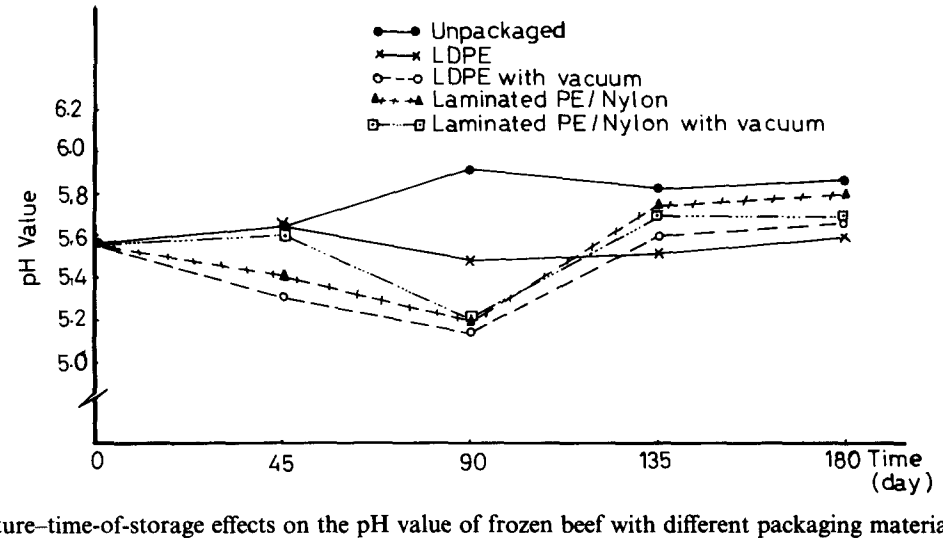

Fig. 2. Temperature–time-of-storage effects on the pH value of frozen beef with different packaging materials and treatments.

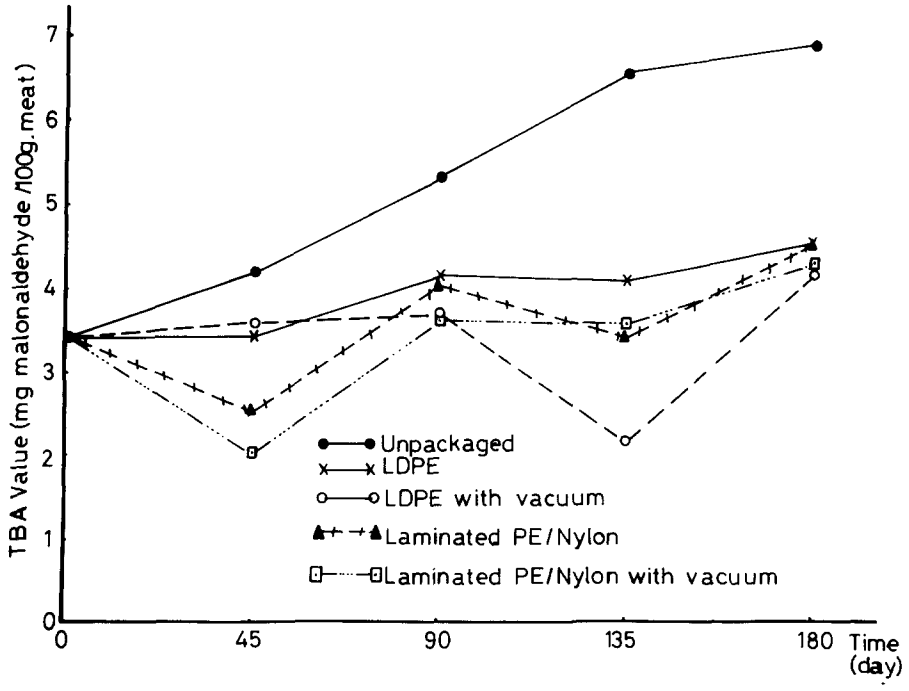

Fig. 3. Temperature–time-of-storage effects on the TBA value of frozen beef with different packaging materials and treatments.

that unpackaged samples had higher pH values than packaged samples during frozen storage.

The differences between the pH values for the frozen samples packaged in two different packaging materials and by two different packaging treatments were not significant ($P < 0{\cdot}05$).

TBA values for treatments at various storage times were plotted as shown in Fig. 3. The values for the unpackaged samples increased significantly ($P < 0{\cdot}01$) during frozen storage, whereas the changes in the TBA values for the packaged samples were not significantly different ($P < 0{\cdot}05$).

Keller and Kinsella (1973) and Igene *et al.* (1980) studied the development of rancidity and deterioration in flavour during frozen storage of meat and found that it was related to the changes in the polyunsaturated fatty acids. Gokalp *et al.* (1984) investigated the effect of packaging treatment on the TBA values of beef patties during frozen storage. They also found a rapid increase in the TBA values in the sample packaged without vacuum. Results showed that the vacuum-packaged samples had lower TBA values, which could have been due to the low level of oxygen inside the package. It was also shown that the differences between the two packaging materials under vacuum treatment were not significant ($P < 0{\cdot}05$).

The conclusion here is that the development of rancidity as a result of lipid oxidation is shown to limit the storage life of unpackaged beef in the frozen state.

The effect of two different packaging materials, two different packaging treatments and time of storage on the water holding capacity (WHC) of frozen beef is

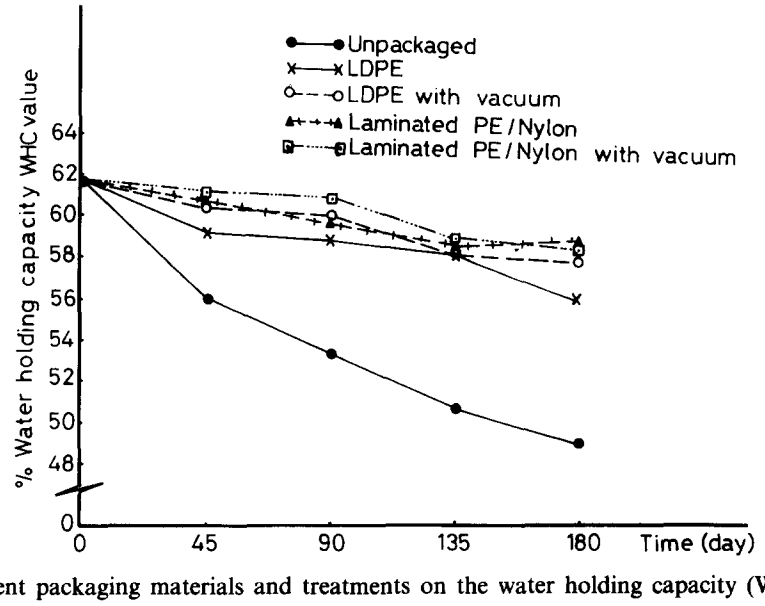

Fig. 4. The effect of different packaging materials and treatments on the water holding capacity (WHC) of frozen beef during storage.

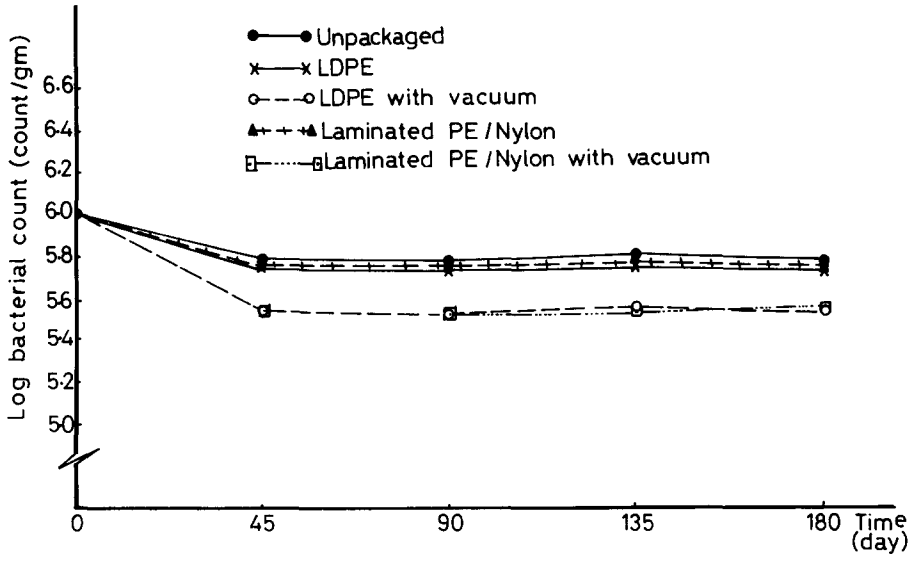

Fig. 5. Temperature–time-of-storage interaction effect on the total aerobic plate count of frozen beef with different packaging materials and treatments.

shown in Fig. 4. The results showed that there was a decline in the WHC values for all samples during storage. this decline was explained by Tsai and Ockerman (1981) as being due to freezing and thawing of the meat damaging the cells and increasing drip losses.

The data show that the unpacked samples had the highest rate of decline in the WHC values. On the other hand, vacuum treatment reduced the rate of decline in WHC.

Temperature plays an important role in determining the growth rate of bacteria on meat surfaces. Cooling increased the lag time and decreases growth rate. The storage temperature will largely dictate the spoilage time (Nortje *et al.*, 1986).

Figure 5 illustrates the temperature–time interaction on the total aerobic plate count of frozen beef with different packaging materials and treatments. The data show a reduction in the total count during the first 45 days of storage for all treatments. Thereafter, the changes in the total bacterial count were not significant ($P < 0{\cdot}05$) during subsequent storage for all treatments. The rate of increase during the first period of storage was much more rapid for the samples packaged under vacuum than for the others. This may have been due to the anaerobic conditions resulting from the vacuum packaging treatment. In conclusion, packaging of beef during frozen storage significantly retarded moisture losses and prevented changes in both the pH and the TBA values. It also reduced the decline in WHC and the total bacterial counts.

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