Extended frankfurter shelf-life under nitrogen

R.E. SIMARD[1], C.L. LALEYE[1], B.-H. LEE[2] and R. HOLLEY[3]

[1]Département de sciences et technologie des aliments and Centre de recherche en nutrition, Université Laval, Ste-Foy, Québec, G1K 7P4.
[2]Agriculture Canada, Station de recherches, St-Jean-sur-Richelieu, Québec, J3B 6Z8.
[3]Food Research Institute, Agriculture Canada, Ottawa, Ontario, K1A 0C6.

Introduction

Newer forms of packaging systems such as vacuum and modified gas atmosphere have been proposed to extend shelf life of various meat products (Finne, 1982; Holland, 1980). Vacuum packaging tends to minimize shrink loss, discolouration and to control growth of common aerobic spoilage bacteria. Storage of meats in modified gas atmospheres has recently been suggested as an alternative to conventional vacuum packaging as a means of retarding microbial spoilage and controlling the colour and shrink loss (Newton et al., 1977).

The effect of nitrogen gas on microbial development of meats is not well established (Christopher et al., 1980). According to Seideman et al. (1979), nitrogen gas (100%) was unimportant to control microflora, except for its ability to minimize weight loss. In contrast, Newton et al. (1977) found that total aerobic plate counts on lamb chops stored in nitrogen were much lower than those of chops stored in air, 80% O_2 - 20% N_2, or in 80% O_2 + 20% CO_2. Recently, sandwiches packed in nitrogen gas have been put on the market (Kauffer et al., 1981); the purpose of the nitrogen package (plastic pouches) was to retard growth of spoilage microflora, thereby extending the shelf-life of the product up to 30 days under refrigeration.

Few studies have been conducted on the effects of vacuum-packed bologna and frankfurters sausages to determine the microbial quality and shelf-life (Nakano et al., 1980; Paradis and Stiles, 1978). However, information is lacking on the effect of nitrogen package compared with vacuum package, on the microbial and sensory quality of frankfurters. This study reports on the microflora and sensory changes of vacuum or nitrogen packaged frankfurters over a 49-day storage period and on the effects of different temperature and light display conditions.

Material and methods

Samples and packaging

Experimental fresh cured frankfurters were purchased directly from the manufacturer (Les Salaisons Brochu Inc., Lévis, Québec) within 12 h of manufacture. All sausages (5 pieces) were aseptically placed at 4°C in gas and vapor low permeable laminated packages (6 x 8¼", Winpak Ltd, Winnipeg) with transmission rates of O_2 (62 cc/m²/24 h/4°C/100% RH), CO_2 (124 cc/m²/24 h/25°C/day) and H_2O (18.6 cc/m²/24 h/37°C/100% RH). Samples in one group were individually vacuum-packed using a chamber-type, heat-seal packaging machine (32 in of Hg). Samples in the other group were injected with 100% nitrogen and sealed in the conventional manner. Packages were randomly assigned to storage periods of up to 49 days at 0, 3 and 7°C under fluorescent light (1030 lux) or dark displays. The samples were stored under controlled temperature (±1°C) and relative humidity (90 to 100%).

Microbial tests

At the end of each storage period, the intact packages were opened aseptically and the sausage cut through a sterile knife. Samples (25 ± 1 g) were placed in 225 mL of sterile 0.1% peptone solution and macerated in a Stomacher-400 (Seyward Lab, London, U.K.) for 1 min.

Psychrotrophic bacterial counts were determined by plating appropriate dilutions with sterile 0.1% peptone on plate count agar (Difco) with plate incubation at 7°C for 10 days. Enumerations of yeasts and molds were done by using acidified potato dextrose agar (Difco) which were incubated at 22°C for 4 days. All plates were made in duplicate.

Subjective evaluations

At the termination of each storage period, individual packages were aseptically opened and frankfurters were subjectively evaluated under 970 lux of incandescent light by four trained evaluators for colour and appearance (greening) and off-odour (souring), using a 4-point scale (4 = no colour change; b = extreme colour change) with c = browning, d = greening, s = souring.

Statistical analysis

Microbiological count data (log 10) and sensory analytical data were treated by using one-way variance analysis with Duncan's multiple range tests. Variance analysis in "split plot" was used to establish the difference between the various treatments. Factorial analysis was also done to compare the effect of darkness and light at four different temperatures for eight storage periods.

Results and discussion

Two experiments were run to determine the extent of variation in numbers of organisms and sensory changes in different samples. The variation in psychrotrophic and yeasts and molds counts are shown in tables 1 and 2 respectively. Sensory changes are shown in table 3. The largest increases in psychrotrophic counts (6.8-7.4 and 8.4-9.4) occurred after 14 days of storage at 7°C, irrespective of different treatments.

Counts of yeasts and molds were relatively constant in vacuum-packed samples stored at 3 and 7°C. But in N_2-packed samples at 3 and 7°C, there was a significant decrease in numbers of yeasts and molds. By comparison, when frankfurters were packed in CO_2, no apparent discolouration was observed (Kraft and Ayres, 1952). Throughout this study, frankfurters packed in vacuum or N_2 generally exhibited stable colours but vacuum packed samples tend to have more surface discolouration due to browning and greening than other samples. Light generally showed more pronounced effect on surface discolouration of vacuum-packed samples than that of N_2-packed samples. Consequently, frankfurters could not be sufficiently stored for 7-21 days in vacuum package. Based on the results of sensory evaluation, it was quite evident that N_2 packaging had significantly increased the storage life by retarding the development of browning and greening and off-odour when compared to comparable vacuum packaging.

References

Christopher, F.M., Z.L. Carpenter, C.W. Dill, G.C. Smith and C. Vanderzant, 1980. Microbiology of beef, pork and lamb stored in vacuum or modified gas atmospheres. J. Food Prot. 43:259-264.

Finne, G., 1982. Modified and controlled atmosphere storage of muscle foods. Food Technol. 36:128-133.

Holland, G.C., 1980. Modified atmospheres for fresh meat distribution. Meat Industry Res. Conference, Chicago, IL, May 27-28.

Kautter, D.A., R.K. Lynt, T. Lilly and H.M. Solomon, 1981. Evaluation of the botulism hazard from nitrogen packed sandwiches. J. Food Prot. 44:59-61.

Kraft, A.A. and J.C. Ayres, 1954. Postmortem changes in stored meats. 4. Effect of packaging materials on keeping quality of self-service meats. Food Technol. 6:8-12.

Nakano, M., Y. Kubokura and M. Ogawa, 1980. Bacterial contamination of vacuum-packed sliced ham and sausages. J. Food Hyg. Soc. 21:260-265.

Newton, K.G., J.C.L. Harrison and K.M. Smith, 1977. The effect of storage in various gaseous atmospheres on the microflora of lamb chops held at -1°C. J. Appl. Bacteriol. 43:53-59.

Paradis, D.C. and M.E. Stiles, 1978. A study of microbial quality of vacuum packaged, sliced bologna. J. Food Prot. 41:811-815.

Seideman, S.C., G.C. Smith, Z.L. Carpenter, T.R. Dutson and C.W. Dill, 1979. Modified gas atmospheres and changes in beef during storage. J. Food Sci. 44:1036-1040.

Acknowledgements

This investigation was supported by the Canada Departement of Agriculture (Contract No. 04SZ.01531-9-0920).

Table 1. Psychrotrophic bacterial counts (log 10/g) of sausages arranged according to packaging treatment and storage interval[1]

Storage (days)	0°C				3°C				7°C				Order of significantly different means 2.5
	Vacuum		N_2		Vacuum		N_2		Vacuum		N_2		
	R[3] A[4]	S B	R C	S D	R E	S F	R G	S H	R I	S J	R K	S L	
0	3.5a	3.9a	3.5a	4.0a	3.5a	3.4a	3.0a	4.0a	4.1a	3.7a	4.0a	3.9a	
3	3.5a	3.5a	4.4a	4.6a	4.0a	3.7a	3.6a	4.1a	4.0a	3.8a	4.2a	4.6ab	
7	3.8a	3.7a	5.0a	4.0a	4.3ab	4.4a	4.0ab	4.6a	4.9a	5.0a	4.3a	6.1bc	
14	4.4a	4.4a	4.9a	4.1a	4.5ab	4.5ab	4.0ab	4.3a	6.8b	7.0b	6.7b	7.4cd	LIJK
21	5.0a	4.1a	4.4a	4.3a	4.4ab	5.6bc	4.5abc	5.2ab	7.9c	7.2b	7.5bc	7.3cd	IKLJF
28	5.2a	4.6a	4.6a	4.9a	5.9bc	6.2cd	5.8bcd	6.6bc	9.1d	8.6b	8.7c	9.0d	ILKJHIFEG
35	4.9a	4.9a	4.8a	4.8a	6.5c	7.0de	6.3bd	7.8c	8.7cd	8.5b	7.9bc	8.7d	HFEGLJK
49	5.0a	4.9a	5.1a	5.8a	7.4c	7.8e	7.4b	7.7c	9.4d	8.4b	9.1c	8.9d	FHEGJKL

[1] abcde means in the same column bearing a common superscript do not differ ($P<0.05$).

[2] Means underscored by a common line are not different ($P<0.05$).

[3] R: dark; S:lighted display.

[4] A,B,C...treatments.

[5] Treatments not shown are not significantly different.

Table 2. Yeasts and molds counts (log 10/g) of sausages arranged according to packaging treatments and storage interval[1]

Storage (days)	0°C Vacuum R[3] A[4]	0°C Vacuum S B	0°C N_2 R C	0°C N_2 S D	3°C Vacuum R E	3°C Vacuum S F	3°C N_2 R G	3°C N_2 S H	7°C Vacuum R I	7°C Vacuum S J	7°C N_2 R K	7°C N_2 S L	Order of significantly different means[2,5]
0	3.4d	3.0a	3.2b	3.2bc	3.6a	2.7a	2.4a	3.3c	3.6a	3.0a	3.8b	3.2b	KG
3	2.5cd	2.7a	2.8b	3.4c	2.6a	2.7a	2.4a	2.4c	2.3a	2.8a	2.5b	2.8b	
7	2.5cd	2.4a	3.1b	2.3b	3.7a	2.0a	2.5a	2.4c	3.7a	2.6a	3.5b	3.2b	F
14	0.6ab	1.0a	2.5b	1.1a	1.2a	0.5a	1.1a	1.0b	3.0a	3.7a	1.2a	0.0a	J
21	0.0a	0.5a	1.1ab	0.5a	1.0a	2.1a	1.3a	0.0a	4.1a	3.8a	0.0a	0.0a	LJ
28	1.1abc	0.0a	1.8ab	0.0a	3.5a	2.4a	0.0a	0.5ab	3.9a	4.6a	1.0a	0.0a	JIE
35	2.0bcd	1.5a	2.3b	0.6a	4.4a	3.6a	0.5a	0.0a	4.0a	4.7a	0.0a	0.0a	JEIH
49	2.1cd	1.5a	0.0a	0.0a	4.0a	3.3a	0.0a	0.0a	3.4a	2.0a	0.0a	0.0a	EIH

[1] abcd means in the same column bearing a common superscript do not differ ($P<0.05$).

[2] Means underscored by a common line are not different ($P<0.05$).

[3] R: dark; S: lighted display.

[4] A, B, C... treatments.

[5] Treatments not shown are not significantly different.

Table 3. Surface colour[1] and off-odor scores[2] of frankfurters arranged according to treatment and storage interval

Storage (days)	0°C Vacuum R[3]	0°C Vacuum S	0°C N_2 R	0°C N_2 S	3°C Vacuum R	3°C Vacuum S	3°C N_2 R	3°C N_2 S	7°C Vacuum R	7°C Vacuum S	7°C N_2 R	7°C N_2 S
0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3	4.0	4.0	4.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5
7	4.0	4.0c	4.0	3.5	4.0	4.0c	4.0c	4.0	4.0	4.0cd	4.0	3.5
14	3.5	4.0c	4.0	3.5	4.0	4.0c	4.0	4.0	4.0	3.0c	4.0	3.5
21	4.0	3.0cd	3.5	3.0	3.5	3.5c	3.0	3.0	3.5	2.5d	3.5	3.0
28	3.0	3.0d	3.0	3.5	3.0	3.5d	2.5	2.5	3.0	2.5d	3.5	2.5
35	2.5	2.5c	2.5	3.5	2.5	2.5d	2.5	2.0	3.0s	2.5ds	3.5	2.0
49	2.5	2.0c	2.5	2.0	2.5s	2.5ds	3.0s	1.5s	3.0s	3.0ds	3.5	2.0

[1] Bases on a 4-point scale (4 = no colour change; 1 = total colour change) with browning (c) or greening (d).

[2] Based on off-odour (s = souring).

[3] R = dark display; S = lighted display.