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BACTERIOLOGICAL CHANGES IN PRE-PACKED PORK DURING STORAGE WITH REFERENCE TO THE GAS COMPOSITION WITHIN THE PACK

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ERRATA

Page	Line	
1	7,19,32)	for microbacteria read Microbacterium thermosphactum
4	8)	
5	11,20)	
10	Table 2)	
4	31	for and read plus
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15	Table 4	The CO_2, O_2 and N_2 levels in the Ventoplas packs (1-5 days) were the same as day 0.

SUMMARY

Bacteriological analyses of the meat and gas analyses of the "atmosphere" within the pack were carried out during the storage of pre-packed pork at 16°C, until spoilage was evident. In the majority of packs Pseudomonas-Achromobacter became the dominant organisms. Other important groups were the lactobacilli and the microbacteria. When the meat was pre-packed, there was a release of CO_2 from the meat within 3 hr. Subsequently the CO_2 level gradually increased. When the bacterial load on the meat had reached 10^8-10^9 organisms/gm, the CO_2 level rose sharply, corresponding to a fall in O_2. There were no major differences in the composition of the flora between the films examined.

ZUSAMMENFASSUNG

Bakteriologische Fleischuntersuchungen und Gasanalysen der Luft innerhalb der Packung wurden während der Lagerung von vorverpacktem Schweinefleisch bei 16°C durchgeführt, bis Anzeichen von Verderbnis erst beobachtet wurden. In den meisten Fällen wurden die Pseudomonas-Achromobacter die vorwiegenden Keime. Andere wichtige Gruppen bestanden aus Laktobazillen und Mikrobakterien. Beim vorverpacktem Fleisch ergab sich binnen drei Stunden eine Freigabe des CO_2 vom Fleisch. Danach stieg der Gehalt an CO_2 allmählich an. Als der Keimgehalt auf dem Fleisch 10^8-10^9 Keime/gm erreichte, erhöhte sich stark die Menge an CO_2, indem der O_2 sich entsprechend verminderte. Es wurden hinsichtlich der Zusammensetzung der Flora keine grossen Unterschiede zwischen den untersuchten Folien gefunden.

RESUME

Des recherches bactériologiques et des analyses de l'air dans l'emballage ont été réalisées pendant le stockage à 16°C du porc pré-emballé, jusqu'à ce que la putréfaction fût apparente. Dans la plupart des cas les Pseudomonas-Achromobacter devenaient les organismes dominants. Les lactobacilles et microbactéries constituaient aussi des groupes importants. Lors du pré-emballage de la viande, un dégagement de CO_2 de la viande s'est produit dans 3 heures. Il s'ensuivait une augmentation progressive de la teneur en CO_2. Quand la charge bactérienne de la viande avait atteint 10^8-10^9 germes/gm, la quantité de CO_2 s'élevait brusquement avec une diminution correspondante du O_2. Aucune différence n'a été trouvé entre les feuilles examinées en ce qui concerne la composition de la flore.

INTRODUCTION

The physical, chemical and microbiological principles of pre-packing meats have recently been reviewed (Selby, 1961; Hansen and Riemann, 1962; Ingram, 1962). It is generally agreed that for fresh meats a film must be gas (O_2) permeable, to maintain the meat pigments in an oxygenated state, and water impermeable, to prevent dessication.

METHODS AND MATERIALS

Preparation of packs

The longissimus dorsi of pigs stored at 4-6°C for 3 days post-mortem was packed into alcohol flamed metal cans (3" diameter, 2.1/16" deep). Muscles were chosen within the ultimate pH range 5.4 - 5.7. Using a metal former, one half of each can was filled with a block of muscle. For each film tested, five such cans were prepared from one l. dorsi, overwrapped and sealed with "Scotch" tape (see Fig. 1). All operations were carried out in the bacon factory. The cans were held at 16°C, the chosen storage temperature, for 3 hr. before the zero analyses were done.

Films

The films tested are listed in Table 1. Each film was examined in duplicate, series I and series II.

Gas analysis

A gas chromatograph (F & M Model 720) was used to analyse the "atmosphere" within the pack for CO_2, O_2 and N_2. Separation of these components was effected by using two columns: A, 1' ($\frac{1}{4}$" O.D.) silica gel (30-60 mesh) at 80°C and B, 6' ($\frac{1}{4}$" O.D.) molecular sieve 5A (30-60 mesh) at room temperature. The columns were connected by means of a 10' ($\frac{1}{4}$" O.D.) copper jumper tube. Before use, the columns were preconditioned: A, by heating over a Bunsen burner for 15 min. and B, by heating in an oven at 149°C overnight (Vosti et al, 1961). The carrier gas was helium (inlet pressure 50 lb/sq.in.) at a flow rate of 120 ml/min. A thermal conductivity detector, operated at 150°C, was used in conjunction with a Minneapolis Honeywell Brown electronic recorder with a sensitivity range of 0.05 to 1.05 mv.

Sampling. A small rubber patch (ca. $\frac{1}{2}$ sq.cm.) was attached to the face of the film, over the "free" gas area. Samples (200 µl) of the "atmosphere" were taken using a gas tight syringe. The sample size allowed the attenuations of x2, x1 and x8 for CO_2, O_2 and N_2

respectively to be employed. A standard gas mixture of CO_2 (11.8%), O_2 (18.9%) and N_2 (69.4%) was used for calibration. A standard was included with each daily set of analyses.

Bacteriological analysis

Immediately after sampling for gas analysis, a slice of approximately 5 mm of the meat surface in contact with the "atmosphere" of the pack was removed, minced, and mixed thoroughly in a polythene bag. All operations were conducted with aseptic precautions. For bacteriological analysis 5.0 gm of mince were shaken vigorously for 2 min. with 45 ml of 0.1% peptone water. Three drops, 0.02 ml each, of each serial dilution in the same diluent were inoculated on to the surface of dried plates by the technique of Davis and Bell (1959). The media and the conditions of usage are shown in Table 2.

The plates were incubated aerobically except AA, which was incubated anaerobically, and all were counted after 48 hr.

RESULTS

Bacteriological changes in pork packed under various films

The results of counts on both the non-selective and selective media are summarized in Table 3.

All meats were deemed spoiled by the 4th day of storage. The total bacterial numbers (NA22) of the meats at this time are shown below:

	Count x 10^6/g		
	Series I	Series II	Average of I and II
Ventoplas	1800	2800	2300
Saran	565	680	622
MSADT	465	351	408
Cryovac XL	88	330	209
Top 35	830	148	489
Pliofilm P16	800	273	537
Polythene	450	830	640
Meatwrap	580	1065	822

Although duplicates of each film were compared, it would still seem that the total bacterial load was consistently highest in the aerobic pack, i.e. Ventoplas. There were no major differences in total counts between the other packs. From this it would appear that the enclosure of fresh pork in a package has some effect on total bacterial growth.

Composition of the flora at the time of spoilage

In the majority of packs the predominant flora at the time of spoilage (3rd-5th day) was Pseudomonas-Achromobacter organisms (MGV). In two cases, Meatwrap I and Pliofilm II, counts on MGV and PKS were approximately the same; in one case, Polythene I, MGV and STAA counts were similar, and in another, Meatwrap II, counts on PKS were greater than those on any other media.

The proportion of the flora recovered on STAA (microbacteria) never exceeded 35% (Cryovac XL I), and in the majority of cases ranged from 2-10%.

Counts on MSA (micrococci) were never greater than 10% (Top 35 II) and in most other packs were less than 1%.

The proportion of the flora classified as lactobacilli (AA) was in general less than 1%. It did, however, increase to 20% (Saran I) and 10% (Cryovac XL II, Top 35 II).

In four packs (Saran I, MSADT I, Top 35 I, and Pliofilm I) the counts on PKS were 20% of the total or more. These packs were prepared at the same time, and in the duplicates (packed at another time) the proportion did not exceed 1%. In some packs (see Table 3) counts on PKS were the same as or greater than any of the other media. PKS medium was found to be suitable for the enumeration of streptococci in comminuted beef (Gardner, 1965), but isolates from this medium in these experiments were all found to be Gram-positive, short, catalase-negative rods. Their identity has not yet been elucidated.

Changes in CO_2, O_2 and N_2 in packs during storage

The results are summarized in Table 4. In most films the CO_2 level rose to 15-20% after 5 days with the exception of Saran, which attained a level of 30%. The increase in the CO_2 level in all packs was accompanied by a corresponding decrease in O_2. However, the CO_2 and O_2 percentage of the atmosphere was not always constant. In the Saran film this percentage rose from 24 to 30.5%, whereas it fell from 23.1 and 24.4 to 15 and 12.4 respectively for Pliofilm and Top 35. It was with the latter two films that the percentage of N_2 increased during storage; in other films it remained at about the initial level.

DISCUSSION

When fresh meat is prepacked, the atmosphere within the pack is initially aerobic. During the storage of pork at 16°C it was found that with most films Pseudomonas-Achromobacter were the predominant organisms. In this respect it would seem that the flora did not differ appreciably from that of "aerobically" stored meats (Ayres, 1963), although he (Ayres, 1960) stated that in meats stored at 15°C or above there was an equal incidence of the genera Micrococcus and Pseudomonas. Other workers have found that the genus Pseudomonas was predominant in refrigerated pre-packed beef (Halleck et al. 1958, Jaye et al. 1962, Stringer 1964, Barlow and Kitchell 1966), lamb (Halleck et al. 1958) and "skinless link-type" sausages (Miller 1964).

In the present work there was an equal number of Pseudomonas-Achromobacter organisms and microbacteria in some of the packs. The latter group have also been found in prepacked minced beef (Jaye et al. 1962), and Miller (1964) found them to predominate with lactobacilli in "wrapped-roll" sausages. Barlow and Kitchell (1966) examined the flora of lamb and beef stored at 5°C in Cryovac XL. After 3 days the flora of the lamb pack was completely dominated (100%) by Microbacterium thermosphactum, while beef treated similarly was found to contain 81.3% Gram-negative flora and the balance made up of strains of M. thermosphactum. In the present work, with pork stored under Cryovac XL, microbacteria varied from 10 to 35% of the total flora. In most of the other packs the proportion ranged from 2 to 10%.

In one of the films (Meatwrap I) counts on PKS exceeded those on MGV, and in Meatwrap II and Pliofilm I there was approximately an equal number of organisms recovered on each medium. When a number of colonies were picked off PKS and examined, all were found to be Gram-positive, catalase-negative, short rods. On total count plates of Saran I, MSADT I, Top 35 I and Pliofilm I, a large number of small pinpoint colonies were noted. When examined, these organisms were similar to those from PKS. In the duplicate run of these films, only a few of these types were noticed on total count plates, and counts on PKS were much lower.

These unknown organisms may belong to the genus Lactobacillus, in which case one would have expected higher counts on AA. This medium is known to be inhibitory for some lactobacilli, e.g. L. viridescens (Jaye et al. 1962), and incubation under strict anaerobic conditions might also be unfavourable for growth of some types.

Halleck et al. (1958) found that lactobacilli comprised about 5% of the flora of pre-packed beef and lamb throughout the refrigerated storage period of 4 weeks, and Jaye et al. (1962) isolated lactic acid bacteria from ground beef stored in Saran (gas impermeable) and cellulose film (gas permeable).

There did not seem to be any substantial difference in the composition of the spoilage flora of the pork between the different films examined. In fact, there were noticeable differences between duplicates of the same film, e.g. Saran, MSADT, Top 35 and Pliofilm. These differences probably arose from a variation in the initial inocula of the meats, which would be accentuated with low counts; the majority of the meats contained < 500 organisms per gm initially. It would seem that more experiments with the same film would be needed to elucidate this anomaly.

The relationship between total bacterial numbers and the CO_2 level (%) for each film examined is shown in Fig. 2(b)(c). For comparison the relationship between CO_2 and total number in pre-packed chicken (Shrimpton and Barnes, 1960) has also been included (Fig. 2(a).

In the aerobic pack (Ventoplas) the CO_2 did not rise during the storage period because of the gas diffusion through the perforations in the polythene.

However, in the second group, i.e. the gas permeable films, the CO_2 level increased rapidly in the first 3 hours to 2-6%. The CO_2 value for air was found to be 0.3%, but this figure cannot be regarded as accurate due to the small quantity (200 µl) analysed. The O_2 level did not change during this initial period, suggesting that CO_2 was released from freshly exposed meat which had been packed within 5-10 min. of preparation. This was found by Urbin and Wilson (1961), who stated that once circulation in the tissues ceases, there is a resultant build-up of CO_2, which in deep muscle is "trapped". When exposed, i.e. during packing operations, gas exchange with air is again possible until a steady-state condition is achieved. These authors stored freshly cut muscle for 24 hr. aerobically before packing and found that the amount of CO_2 released was very noticeably decreased.

Subsequently in the pork packed in gas permeable films the CO_2 level gradually increased until the bacterial numbers had risen to 10^8 to 10^9 organisms per gm; at this stage the CO_2 level rose sharply. There seemed to be little variation in the bacterial count/CO_2 relationship between the six gas permeable films examined. However, the $CO_2 + O_2$ value for most gas permeable films was constant with the exception of Pliofilm and Top 35, where there was a fall in this value. This corresponded to an increase in the N_2 level. A possible explanation may be that these films were more permeable to CO_2 than O_2, which "leaked" out of the can, thus depressing the $CO_2 + O_2$ level. This would suggest a negative pressure inside the can.

There was a linear relationship between time and CO_2 level for the gas impermeable film (Saran). The CO_2 + O_2 level increased during storage, without an increase in the N_2 level. This appeared to result from CO_2 production by the meat and by bacteria and may be explained by the noticeable build-up of pressure inside these packs. Jaye et al. (1962) noted that Saran packed meats appeared inflated after 6 or more days at 3°C. They demonstrated that the gas was primarily CO_2 which resulted from the heterofermentative metabolism of lactic acid type bacteria. It seems likely that other bacteria would also contribute to the CO_2 build-up. Shrimpton and Barnes (1960) found greatest increases in CO_2 in chickens packed in vinylidine chloride-vinyl chloride polymer film, and stored at 1°C (see Fig. 2 (a), when compared with polyethylene and a modified (heat shrinkable) polyethylene. When the chickens had spoiled, however, the CO_2 level in vinylidine chloride-vinyl chloride copolymer film had increased to 10%.

In some preliminary work with pork stored at 4°C in MSADT (author's unpublished observations) the rate of increase in CO_2 and the final level when the meat was spoiled was markedly lower than at 16°C.

From these results it would seem that when meat, freshly prepared, is packed, there is an immediate physical release of CO_2 from the tissues into the atmosphere. The meat, however, continues to release CO_2 at a reduced rate. At this time the gas can diffuse through the gas permeable films as fast as it is produced, but it is not until there is gross bacterial contamination (10^8 - 10^9 organisms/gm) that the CO_2 production exceeds the films' permeability.

It is well known that CO_2 inhibits the growth of many microorganisms. It was not until the 3rd-5th day of storage that the level rose to 10-20%. At this stage the total bacteria numbers were greater in the "aerobic" (Ventoplas) packs than in any of the other packs. This inhibition may be attributed to CO_2, but from the analyses of the flora it would seem that it depressed the growth of the majority of the bacteria present. Kovats et al. (1959) stated that packaging raw pork and beef seemed to partially inhibit the growth of bacteria, and Halleck et al. (1958) reported that the packaging material did not selectively affect the growth of the predominant genera.

Even when the pork was spoiled, there was still at least 1% oxygen in the atmosphere, which according to Ingram (1962) is adequate for most organisms to saturate the aerobic systems and maintain respiration and growth rates at the level in air. It is also known that CO_2 inhibits bacterial growth more effectively at low temperature (Ogilvy and Ayres, 1951). Ogilvy and Ayres (1953) found that frankfurters stored under CO_2 had a longer shelf life at -1°C than at 10°C. Therefore the inhibitory effect of the CO_2 on the flora of the packs stored at 16°C may be low enough to allow the aerobic (Pseudomonas-Achromobacter) flora to remain predominant. The possibility that the more CO_2 tolerant bacteria, e.g. lactobacilli, may supersede the Pseudomonas-Achromobacter has not been ruled out, as organisms resembling this type have been found in the meats. Halleck et al. (1958) thought that the dominant genera, Achromobacter-Pseudomonas organisms, created conditions favourable for the growth of lactobacilli. However, it is felt that the technique used in these experiments for enumerating lactobacilli was inadequate, and in further work in this field the flora composition would be more accurately determined by screening isolates from total count plates. This is further substantiated by the fact that the total of selective media in some cases was widely different from the results of the total plate counts.

Fig: 1 Method of pre-packing

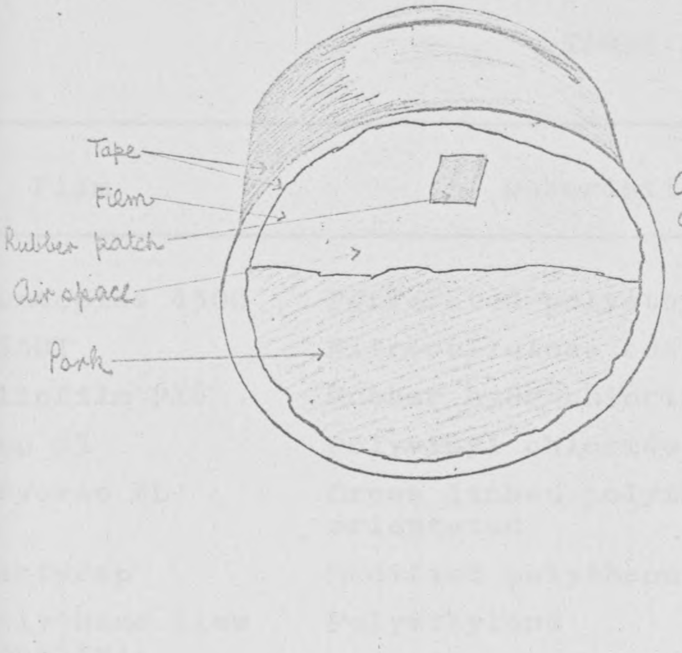
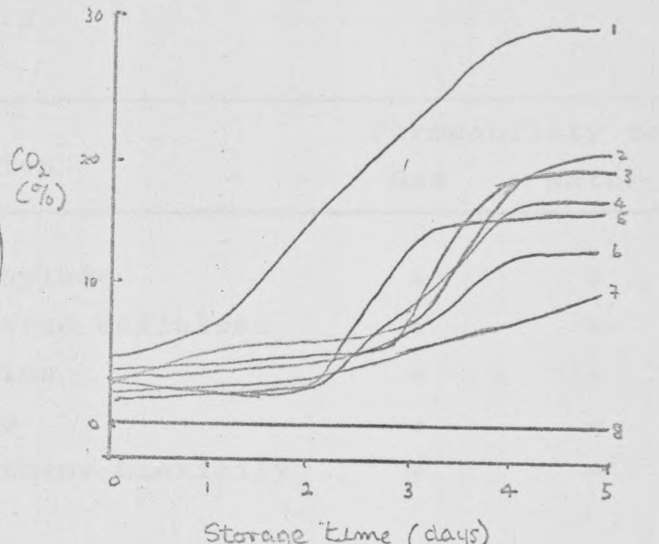


Fig: 3 The levels of CO_2 of "atmosphere" within packs of pork stored under various films* (average of two experiments).



* 1, Saran; 2, Polythene; 3, Cryovac XL; 4, MSADT; 5, Meatwrap; 6, Pliofilm; 7, Top35; 8, Ventoplas.

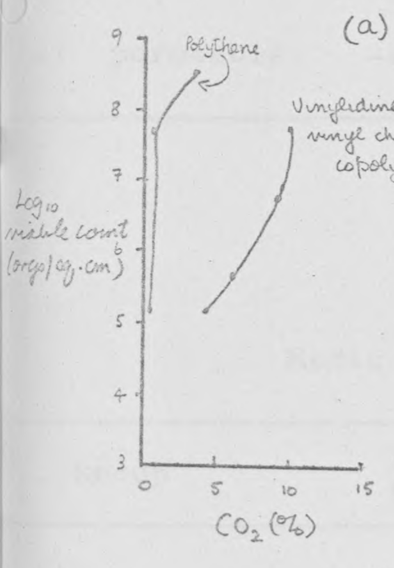


Fig: 2. Relationships between bacterial numbers and CO_2 in pre-packed meats:
(a) Chickens (Shrimpton + Barnes, 1960.)
(b) + (c) pork under various films*

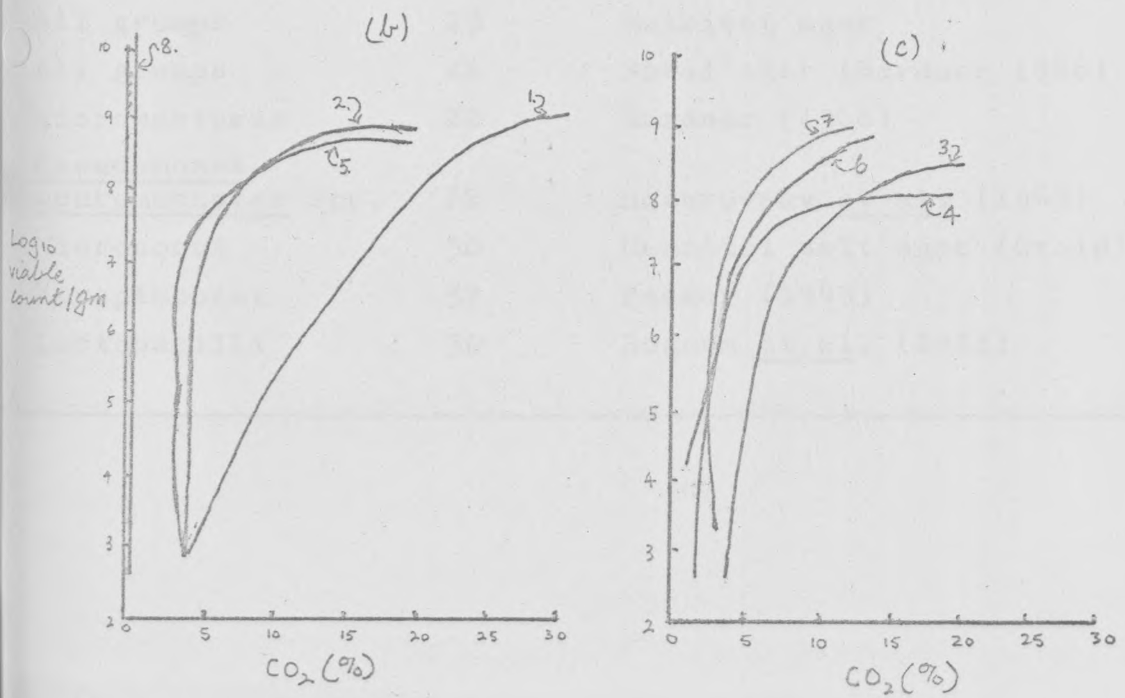


TABLE I

Film	Description	Permeability to Gas	Permeability to Water
Ventoplas 4500	Perforated polyethylene	+	+
MSADT	Nitrocellulose coated cellulose	+	-
Pliofilm P16	Rubber hydrochloride	+	-
Top 35	Polyvinyl chloride	+	-
Cryovac XL	Cross linked polythene biaxially orientated	+	-
Meatwrap	Modified polythene	+	-
Polythene (low density)	Polyethylene	+	-
Saran	Vinylidine chloride-vinyl chloride copolymer	-	-

+: permeable -: impermeable

TABLE 2

Media used for evaluating the flora of meats

Group	Incubation temp. (°C)	Medium	Abbreviation
All groups	22	Nutrient agar	NA22
All groups	22	Basal agar (Gardner 1966)	BA
Microbacteria	22	Gardner (1966)	STAA
Pseudomonas-Achromobacter spp.	22	Masurovsky et al. (1963)	MGV
Micrococci	30	Mannitol salt agar (Oxoid)	MSA
Streptococci	37	Packer (1943)	PKS
Lactobacilli	30	Rogosa et al. (1951)	AA

TABLE 3

Counts on media of pork stored under various films

Film: Ventoplas 4500 — Count (x10^6/g) — Series I

Storage time (days)	0	1	2	3	4	5
Medium						
NA22	0.0025	0.60	83	*	1800	2950
Basal	0.0031	0.65	45.6	*	1565	2550
STAA	-	0.016	0.86	*	25	45
MGV	-	0.61	12.5	*	75	2580
PKS	-	-	-	*	0.45	36.5
AA	-	-	-	*	0.0086	4.45
MSA	0.0025	0.0046	0.11	*	16.5	28.1

Series II

Medium	0	1	2	3	4	5
NA22	-	*	26.1	*	2800	3300
Basal	-	*	18	*	2800	*
STAA	-	*	13.3	*	330	465
MGV	-	*	6.0	*	715	4000
PKS	-	*	3.5	*	30	4.3
AA	-	*	0.73	*	14.5	11.1
MSA	-	*	0.1	*	4.0	6.5

Film: MSADT — Count (x10^6/g) — Series I

Storage time (days)	0	1	2	3	4	5
Medium						
NA22	0.001	*	8.65	1100	465	3150
Basal	-	*	10	430	315	3800
STAA	-	*	0.23	61.5	7	81.5
MGV	-	*	1.71	265	260	122
PKS	-	*	4.15	38	50	100
AA	-	*	0.09	5.8	*	5.3
MSA	-	*	0.18	16.6	26.5	4.5

Series II

Medium	0	1	2	3	4	5
NA22	0.0028	*	19.25	230	351	630
Basal	0.0013	*	11.65	265	250	480
STAA	-	*	0.45	5.75	15.3	12.65
MGV	-	*	6.23	265	398	210
PKS	-	*	-	-	0.016	0.12
AA	-	*	-	0.061	0.7	0.095
MSA	-	*	0.7	10	2.46	7

TABLE 3 (ctd.)

Film: Cryovac XL			Count ($x10^6$/g)			Series I
Storage time (days)	0	1	2	3	4	5
Medium						
NA22	-	0.003	0.21	*	88	185
Basal	-	0.002	0.18	*	81.5	196
STAA	-	-	0.13	*	31.3	27.1
MGV	-	-	0.0016	*	14	235
PKS	-	-	-	*	9.3	20.3
AA	-	-	-	*	0.02	0.14
MSA	-	0.0016	0.014	*	3.5	7.1
						Series II
Medium						
NA22	-	*	3.0	*	330	216
Basal	-	*	2.66	*	465	288
STAA	-	*	0.9	*	46	36.5
MGV	-	*	0.016	*	180	168
PKS	-	*	0.7	*	55	6.6
AA	-	*	0.25	*	16.2	30.5
MSA	-	*	0.015	*	4.0	0.2

Film: Top 35			Count ($x10^6$/g)			Series I
Storage time (days)	0	1	2	3	4	5
Medium						
NA22	0.004	*	46.5	400	830	1180
Basal	0.0036	*	76.5	400	780	1180
STAA	-	*	1.95	11.8	12.1	33
MGV	-	*	1.31	265	550	400
PKS	-	*	53	115	140	248
AA	-	*	0.04	2.3	*	45
MSA	-	*	0.85	3.65	1.16	1.8
						Series II
Medium						
NA22	0.0021	*	0.68	83	148	93
Basal	0.0025	*	0.80	93	136	133
STAA	-	*	0.15	1.65	17	15.5
MGV	-	*	0.16	19.6	13.5	33
PKS	-	*	0.0011	-	0.0046	-
AA	-	*	-	0.9	0.31	10.3
MSA	-	*	0.15	3.6	19.8	7.0

Table 3 (ctd.)

Film: Pliofilm P16			Count ($x10^6$/g)			Series I
Storage time (days)	0	1	2	3	4	5
Medium						
NA22	0.006	*	19	180	800	400
Basal	0.0058	*	25.1	330	1000	350
STAA	-	*	1.6	12.8	21.8	13.6
MGV	-	*	3.6	105	115	193
PKS	-	*	16.1	105	226	*
AA	-	*	0.07	5.5	*	7.5
MSA	-	*	0.63	2.15	1.71	2.3
						Series II
Medium						
NA22	-	*	24.15	66.5	273	1365
Basal	-	*	16.3	86.5	250	1080
STAA	-	*	8.3	6.65	30.1	226
MGV	-	*	12	26.5	100	650
PKS	-	*	0.0006	1.47	0.02	0.76
AA	-	*	-	5.3	4.8	10.1
MSA	-	*	0.31	1.41	2.35	18.75

Film: Polythene			Count ($x10^6$/g)			Series I
Storage time (days)	0	1	2	3	4	5
Medium						
NA22	-	0.046	17.1	*	450	160
Basal	0.0006	0.051	17.6	*	730	163
STAA	-	0.019	5.3	*	166.5	39.8
MGV	-	0.0028	0.024	*	170	33
PKS	-	-	0.056	*	80	0.12
AA	-	-	0.0036	*	0.0095	-
MSA	-	0.0013	2.41	*	12.5	12.0
						Series II
Medium						
NA22	0.012	*	2.0	*	830	1850
Basal	0.01	*	2.16	*	800	*
STAA	-	*	0.35	*	81.5	168
MGV	0.009	*	0.53	*	490	1350
PKS	-	*	0.9	*	45	4.65
AA	-	*	0.17	*	16.7	8.3
MSA	-	*	0.009	*	0.5	10.1

TABLE 3 (ctd.)

Film: Meatwrap			Count (x10^6/g)			Series I
Storage time (days)	0	1	2	3	4	5
Medium						
NA22	-	0.04	16.8	*	580	515
Basal	-	0.04	15.8	*	630	430
STAA	-	0.0008	0.21	*	23.6	11.6
MGV	-	0.015	0.27	*	18.1	*
PKS	-	-	0.011	*	128	12
AA	-	-	-	*	0.009	-
MSA	-	0.006	0.48	*	23	20.5
						Series II
Medium						
NA22	-	*	*	*	1065	1100
Basal	-	*	*	*	1115	1050
STAA	-	*	*	*	115	145
MGV	-	*	*	*	900	1080
PKS	-	*	*	*	1165	*
AA	-	*	*	*	5.6	10.6
MSA	-	*	*	*	0.18	2.2

Film: Saran			Count (x10^6/g)			Series I
Storage time (days)	0	1	2	3	4	5
Medium						
NA22	0.0008	*	7.3	500	565	171
Basal	-	*	6.6	650	500	158
STAA	-	*	0.63	21.6	36.5	31.5
MGV	-	*	0.5	400	141	78
PKS	-	*	3.3	1.66	43.2	32.5
AA	-	*	0.06	13.5	*	30
MSA	-	*	0.5	2.0	1.05	2.0
						Series II
Medium						
NA22	0.0036	*	16.8	230	680	1000
Basal	0.0021	*	16	160	530	780
STAA	-	*	1.0	3.0	4.8	8.8
MGV	-	*	7.5	217	500	168
PKS	-	*	0.0025	0.0056	0.065	1.8
AA	-	*	-	0.96	0.0198	4.7
MSA	-	*	0.06	0.38	1.98	12.1

*: not tested -: less than 500 organisms/g.

TABLE 4

The composition (%) of the "atmosphere" within the pack

Film	Storage at 16°C (days)											
	0		1		2		3		4		5	
Saran												
CO_2	4.0	5.7	-	7.1	15.5	3.7	24.3	20.2	29.7	29.7	29.7	29.0
O_2	19.5	19.9	-	14.7	13.9	20.9	5.0	8.0	1.0	1.1	1.2	1.2
N_2	72.8	76.2	-	61.6	67.2	85.1	76.2	79.5	71.7	79.5	69.4	76.2
CO_2+O_2	23.5	25.6	-	21.8	29.4	24.6	29.3	28.2	30.7	30.8	30.9	30.2
Pliofilm PT6												
CO_2	3.0	2.0	-	4.4	4.7	5.4	6.7	7.8	12.1	13.5	12.8	14.2
O_2	20.1	21.1	-	16.9	16.1	18.1	14.7	14.3	4.8	1.3	1.2	1.8
N_2	76.2	80.6	-	70.6	78.4	85.1	82.9	85.1	85.1	94.1	81.8	85.1
CO_2+O_2	23.1	23.1	-	21.3	20.8	23.5	21.4	22.1	16.9	14.8	14.0	16.0
Top 35												
CO_2	3.7	3.9	-	3.0	5.4	3.7	7.2	3.7	9.1	7.2	13.5	8.1
O_2	19.5	21.3	-	13.7	15.3	18.9	11.1	17.7	1.4	10.5	1.4	1.8
N_2	75	76.2	-	80.6	80.6	87.4	86.2	85.1	90.7	93.0	82.9	95.2
CO_2+O_2	23.2	25.2	-	16.7	20.7	22.6	18.3	21.4	10.5	17.7	14.9	9.9
Cryovac XL												
CO_2	4.0	4.4	7.4	-	6.1	7.1	7.8	-	20.9	17.5	19.5	17.5
O_2	20.1	20.1	18.1	-	18.5	16.9	15.3	-	1.2	1.3	1.2	1.3
N_2	71.7	71.7	73.9	-	73.9	69.4	73.9	-	73.9	80.6	73.9	72.9
CO_2+O_2	24.1	24.5	25.5	-	24.6	24.0	23.1	-	22.1	18.8	20.7	18.8
MSADT												
CO_2	3.4	2.7	-	2.9	2.0	5.1	10.8	9.1	5.7	16.9	18.2	14.8
O_2	19.5	20.5	-	14.5	19.7	18.5	12.1	12.7	16.9	3.8	5.0	1.8
N_2	73.9	78.4	-	81.8	77.3	81.5	81.8	85.1	80.6	91.8	73.9	85.1
CO_2+O_2	22.9	23.2	-	17.4	21.7	23.6	22.9	21.8	22.6	20.7	23.2	16.6
Polythene												
CO_2	4.0	4.6	6.4	-	5.4	4.0	7.4	-	20.2	17.5	22.9	18.2
O_2	19.3	19.7	18.9	-	19.3	18.5	16.5	-	5.0	5.0	1.4	6.1
N_2	71.7	71.7	73.9	-	73.9	71.7	73.9	-	73.9	73.9	73.9	73.9
CO_2+O_2	23.3	24.3	25.3	-	24.7	22.5	23.9	-	25.2	22.5	24.3	24.3
Meatwrap												
CO_2	4.0	4.7	2.9	-	3.0	3.7	14.5	-	14.8	16.2	15.5	16.9
O_2	19.3	19.9	20.1	-	20.1	19.3	2.0	-	1.4	2.0	1.2	2.1
N_2	71.7	75.0	73.9	-	73.9	72.8	80.6	-	80.6	80.6	73.9	72.8
CO_2+O_2	23.3	24.6	23.0	-	23.1	23.0	16.5	-	16.2	18.2	16.7	19.0
Ventoplas												
CO_2	T*											
O_2	20.5											
N_2	73.9											

T*: trace

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