AD

TECHNICAL REPORT
FD-34

STORAGE LIFE OF FROZEN FRANKFURTERS

by

S. SIMON
W. KRAMLICH
D. DIEBALL
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VISKING COMPANY
Division of Union Carbide Corporation
Chicago, Illinois

Contract No. DA 19-129-QM-1790

November 1965

U. S. Army Materiel Command
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts

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FOREWORD

To avoid microbiological deterioration during the extended periods required for overseas shipment and distribution, frankfurters, bologna, and perishable luncheon meats are maintained in the frozen state. For many years the frankfurters supplied to our overseas forces have been the source of recurring dissatisfaction ranging from inferior acceptability to outright condemnation as unwholesome. Laboratory examination has established that condemnation resulted from changes associated with the oxidative rancidity of the fat. The time required for the development of rancidity varied widely with frankfurters from different suppliers and even from the same supplier at different times. An occasional lot would exhibit well developed rancidity after two months frozen storage while other lots remained free from rancidity after eleven months. A study of different formulations and modifications of commercial processing operations failed to reveal a feasible means of preventing the rapid development of rancidity in frozen frankfurters.

As a practical alternative this study seeks to develop an objective test to differentiate between lots of frankfurters which have adequate frozen storage life and lots predisposed to early development of rancidity. Application of such a test at the time of procurement would eliminate from overseas supply lines frankfurters of inadequate or questionable stability and thereby avoid losses through condemnation.

The study herewith reported was performed by the Visking Division of the Union Carbide Corporation, 6733 West 65th Street, Chicago 38, Illinois, under the contract DA19-129-QM-1790. Funds were provided from the Applications Engineering Project, 2210.8. The investigation was conducted under the general supervision of Mr. F. Warren Tauber, Manager of Food and Packaging Development. Dr. Selwyn Simon served as Official Investigator; Dr. Donald Dieball, Dr. William Kramlich and Miss Ruth Yotter were collaborators. The Project Officer for the U. S. Army Natick Laboratories was Dr. Maxwell C. Brockmann of the Animal Products Branch, Food Division. Alternate Project Officer was Mr. Albert S. Henick, of the Food Chemistry Branch, Food Division.

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SUMMARY

Frankfurters prepared in accordance with standard commercial formulations and processes simulated the rancidity pattern observed under field conditions. Some experimental lots were evaluated as rancid after 2 to 3 months storage at 0 to -10°F; other lots were found to be free of rancidity after 6 months. Experiments involving the use of prooxidants or exposure to ultraviolet radiation showed no promise of differentiating between frankfurters undergoing rapid and slow oxidative changes during frozen storage. Observations were performed on the suitability of the thiobarbituric acid (TBA) test and on the determination of volatile reducing substances (VRS) to the identification of frankfurters predisposed to rapid development of rancidity. Neither of these tests, even when used in conjunction with accelerated storage conditions, was found suitable for predicting the onset of rancidity during frozen storage.

INTRODUCTION

Owing to long delays in transportation, storage and distribution, the frankfurters destined for overseas use are maintained in the frozen state until prepared for consumption. From time to time it has been found that frozen frankfurters become gray, lose flavor, and develop rancid characteristics. Laboratory tests clearly establish that this deterioration is associated with a high peroxide value and other changes indicative of autocatalytic fat oxidation. Condemnation of frankfurters for rancidity has, at times, caused substantial economic losses; in addition there has been a recognized loss of acceptability of frankfurters among overseas forces which is presumed to be caused by an incipient form of rancidity.

Previous studies have failed to reveal a feasible means of preventing the development of rancidity in frozen frankfurters. As an alternative, this project seeks to develop an objective test to identify frankfurters. As an alternative, this project seeks to develop an objective test to identify frankfurters which are especially susceptible to oxidative changes during storage in the frozen state. Such a test when judiciously applied under end-item inspection could provide for the exclusion from overseas supply lines of frankfurters susceptible to the rapid development of rancidity and thus improve the quality and acceptability of frankfurters available to our forces abroad.

Frankfurter Composition

	60 Beef/40 Pork	40 Beef/60 Pork
Boneless chuck	15 lbs.	10 lbs.
Regular pork trim	10 lbs.	15 lbs.
Ice	8-3/4 lbs.	8-3/4 lbs.
Salt	12 oz.	12 oz.
Dextrose	3 oz.	1-1/8 oz.
Pepper	1-1/8 oz.	1/2 oz.
Nutmeg	1/2 oz.	1/2 oz.
Coriander	1/2 oz.	1/2 oz.
Red pepper	1/4 oz.	1/4 oz.
Cure (Commercial Nitrate-Nitrite)	1 oz.	1 oz.

Proximate Analysis

Frankfurter	% Moisture	% Fat	% Protein	% Ash
60 Beef/40 Pork	56-60	24-28	12-13	2.5
40 Beef/60 Pork	52-55	29-33	10-11	2.7

PROOXIDANTS

Introduction. Driers act by promoting rapid oxidation and drying either at the surface, or throughout films containing them. It was thought that the application of a drier to the surface of a frankfurter would promote the rapid oxidation of the frank surface pigments. Then the extent of discoloration on frankfurters of variable quality and/or time required to produce the discoloration could be associated with the expected shelf life of the frankfurter. Six such driers were obtained from our Ink Laboratory and used to paint the surface of the frankfurters. The driers used in this investigation were as follows:

1. Zirco drier catalyst (6% zirconium). Generally, zirconium is not used alone as a drier, but in combination with other driers because of its strong synergistic action. It can replace large percentages of the elements (such as lead, manganese, and cobalt) in a drier mixture.

2. Hexogen rare earth octoate 4%. This is a specially prepared metallic soap solution in mineral spirits of rare earth metals (mainly lanthanum and cerium in equal proportions).

3. Soligen rare earth naphthenate 4%. The soligen drier is the same as #2 above except naphthenic acid replaces the 2-ethyl hexoic acid.

4. Iron (6%). Iron is most active at elevated (above ambient) temperatures.

5. Cobalt (12%). Cobalt is the most powerful metallic drier known today.

6. Lead (25%). Lead is the most popular metallic drier used today in the paint industry. It is a relatively slow acting drier.

Experimental. Driers were applied both to frankfurters and fresh meats. Three sets of franks were used for the initial testing. These included:

(a) two day old all-meat franks made in our laboratory (60 beef/40 pork formulation with 30 lbs./cwt. added moisture);

(b) frankfurters made in our laboratory containing a protein flour extender, and 16 days old when used;

(c) heavily smoked commercial frankfurters that were at least 9 days old.

Franks from groups a, b, and c were dipped in the drier liquid and placed in a metal tray. The tray, in turn, was placed in a 40°F cooler. Another set of franks representing groups a, b, and c were dipped in the various driers, placed in a metal tray and held at room temperature.

In both cases observations were conducted immediately and periodically up to 16 hours. The results are tabulated below:

	Color Change in Franks	
Drier	Stored at 40°F.	Room Temperature
Zirco	None	None
Hexogen	None	None
Rare earth Naphthenate	a and b - very slightly whitened c - none	a and be - very slightly whitened c - none
Iron	All stained reddish brown immediately	All stained reddish brown immediately
Cobalt	All stained purple immediately	All stained purple immediately
Lead	a and b - tended to whiten immediately c - turned a yellowish brown	a and b - tended to whiten immediately c - turned a yellowish brown

When a drier was applied to a frankfurter, either no significant color change occurred or else the frank was stained immediately as when iron or cobalt were used. With lead and rare earth naphthenate , the heavy smoke on the c franks perhaps masked the whitening effect noted on the a and b franks producing the results noted in the table above.

The same prooxidants were applied to both chunks and ground pork jowl fat. One set of treated chunks and one of the treated ground fat were placed in a 100°F oven and observed periodically. Another set of each were placed in a 40°F cooler and held for observation.

Zirco, Hexogen, and naphthenate made no perceptible visual color impression on the fat samples, either chunked or whole. The iron stained both samples a reddish brown immediately upon application and the cobalt stained the samples purple immediately upon being applied. Lead had no effect on the fat chunks, but turned the ground fat a light tan immediately upon being applied. No differences were noted between samples held in the refrigerator or the oven.

Aside from the work with paint driers, some testing was done with ultra-violet radiation to accelerate oxidation.

Ultra-violet radiation. Six samples of meat were subjected to the direct rays of an ultra-violet lamp. The samples were as follows:

1. ground jowls (12 days old);
2. whole jowls cut in approximately 1' cubes (12 days old);
3. surface of vienna style franks, uncanned (7 days old);
4. interior of vienna style franks, uncanned (7 days old);
5. surface of franks prepared with mustard flour (16 days old);
6. interior of franks prepared with mustard flour (16 days old).

The samples were subjected to the light rays (5" from the lamp) for four hours. Periodic examination of the products indicated no significant color changes took place. Due to the heat generated by the lamp, all the samples tended to brown slightly, but no particular significance could be attached to this phenomenon.

VOLATILE REDUCING SUBSTANCES

Introduction. The analytical method developed by Farber and Ferro (1956) for detecting spoilage in raw fish was adopted as a basis for this study. The method consists of absorbing in a standard alkaline permanganate solution the VRS swept from the sample. The excess permanganate is determined by reacting it with potassium iodide and titrating the liberated iodine with sodium thiosulfate. The chemistry is as follows:

1) $MnO_4^- + (VRS)_R \xrightarrow{OH^-} MnO_2 + (VRS)_o$

2) (Excess) $2MnO_4^- + 10I^- + 16H^+ \longrightarrow 2Mn^{++} + 8H_2O = 5I_2$

3) $I_2 + 2S_2O_3 = \longrightarrow 2I^- + S_4O_6 =$

The data are reported in terms of the volume of thiosulfate equivalent to the permanganate which has reacted with the volatile reducing compounds in the meat sample, and is calculated from the following formula:

$$\mu\text{eq. VRS} = \frac{\text{ml. } Na_2S_2O_3(1) - \text{ml. } Na_2S_2O_3(2) \times N\ Na_2S_2O_3 \times 1000}{\text{Weight of dry sample (gm.)}}$$

(1) = ml. $Na_2S_2O_3$ to react with 10 ml. of standard $KMnO_4$

(2) = ml. $Na_2S_2O_3$ to react with volume of standard $KMnO_4$ in excess

Experimental. Preliminary work has been devoted to finding a technique for rapidly removing all the volatiles from the meat. To date, three general techniques have been investigated concerning the treatment of the sample. These included the use of press juice, meat slurry, or ground meat.

A. Press Juice. Following the lead of Farber and Ferro attempts were made to press liquid containing the VRS from chopped and ground frankfurters. This approach was unsuccessful in that too little press juice was obtained using an ordinary Carver Press at 20,000 psi. Even if adequate quantities of press juice could be obtained it would be difficult to equate the VRS found

by analysis to the original sample size since the distribution coefficient of VRS in the meat-press juice substrates also would be an unknown. Consequently, attempts were made to remove the VRS from a meat slurry.

B. Meat Slurries. Samples were prepared by grinding the meat samples and slurrying weighed amounts with measured quantities of water. The following techniques were used in analyzing the VRS content in the slurry:

1) The Farber and Ferro method was used as described, i.e., by re-cycling air with a finger pump through the slurry in the reaction flask and the permanganate absorber flask. Sample data are tabulated below for a 50 g. slurry containing 30 g. of ground franks.

Total Elapsed Time	VRS Equivalent/Hr.
1 Hour	0.74
2 Hours	0.77
3 Hours	0.77
4 Hours	0.73

These data suggested that during the re-cycling additional oxidation occurred in the meat sample, thereby resulting in abnormally high total values of VRS.

2) Removal of VRS by Nitrogen Flushing a Meat Slurry.

A series of experiments were run to study the recovery of VRS by flushing the meat slurry with nitrogen. Representative data for ground frankfurters are tabulated below.

Sample Size and Condition					
1 Gm. Slightly Rancid		2 Gm. Highly Rancid		5 Gm. Highly Rancid	
Total Elapsed Time (Hr.)	VRS/Hr./ Gm.	Total Elapsed Time (Hr.)	VRS/Hr./ Gm.	Total Elapsed Time (Hr.)	VRS/Hr./ Gm.
1	0.20	1	0.23	1	0.15
2	0.15	2	0.21	2	0.14
3	0.12	3-3/4	0.25	3	0.14
5	0.04	5-1/4	0.23	4	0.13
-	-	-	-	5	0.15

Analysis of these data indicates that the rate of VRS removal from the slurry is affected primarily by sample size but to little or no extent by the degree of rancidity (VRS content). All VRS may be removed from relatively fresh samples in several hours; the VRS content of rancid samples is not markedly depleted in five to six hours.

These conclusions were further substantiated by the results, shown below, for ground beef slurries.

Sample Size and Condition			
5Gm. Fresh		1.5 Gm. Rancid	
Total Elapsed Time (Hr.)	VRS/Hr./ Gm.	Total Elapsed Time (Hr.)	VRS/Hr./ Gms.
1	0.05	1	0.22
3	0.04	2	0.19
4-1/4	0.029	3-1/2	0.14
5-1/2	0.008	6-1/3	0.18

Using larger sample sizes for analyzing fresh samples yielded larger titration values but required excessive analysis time.

These data, indicating a need for more rapid analysis, led to the nitrogen flushing technique discussed below.

C. VRS Removal by Nitrogen Flushing Meat Sample Per Se. It seemed possible that the VRS might be in equilibrium with the water in the slurry, making it difficult to remove from the sample. To check this theory a 1 g. sample of highly rancid beef (same beef as used in B, 2) was placed in a sample tube and flushed with nitrogen. A schematic diagram of the apparatus is shown in Fig. 1. Volatiles were absorbed in alkaline permanganate and the solutions analyzed as before. The data, shown below, indicate a more rapid removal of VRS.

Total Elapsed Time (Hrs.)	VRS/Gm.
0.5	5.12
1.0	3.10
1.5	1.98
2.0	1.23
2.5	1.09
3.0	0.76
3.5	0.70
4.0	0.54
4.5	0.37
5.0	0.51
5.5	0.17

Recovery of VRS. Tests were conducted in order to determine the effect of sample size, temperature and time on VRS recovery. The recovery of VRS from beef samples held for 3 days at 40°F is shown in Figure 2 as a function of sample weight, sample temperature, and purging time. Decreasing sample size and increasing sample temperature increased the initial rate of VRS liberation but did not reduce appreciably the 6-1/2 hour time required to achieve 100 per cent recovery.

Similar results are shown in Figure 3 for a 1.0 gm. highly rancid frankfurter sample.

Formation of VRS in Beef and Frankfurters. Three sets of frankfurters were prepared from an emulsion containing 60% beef chuck and 40% pork trimming in the meat block; and stored at 40°F with the original raw beef. Set differences included: (a) franks with no cure; (b) franks with cure; and (c) franks with cure and ascorbic acid.

Each of the four samples was analyzed daily for VRS content. The results for raw beef are shown in Figure 4 and those for the franks in Figure 5.

During storage, deterioration in the beef sample was evidenced by increasing noxious odors and tackiness in the specimen, and was accompanied by an increase in VRS content. The latter reached a maximum after three days storage at 40°F. the VRS content decreased after three days of storage whereas off-odor increased. It was noted also that the nitrogen purged samples retained some of their odors even after the VRS had been completely removed.

The following experiment was conducted in order to determine whether or not the odor retained by the sample after nitrogen purging had a VRS value. Duplicate beef samples were analyzed for VRS content - one sample being maintained at 23°C and the other at 85°C during purging. Although VRS levels essentially were identical for the two samples (61 and 69, respectively), the heated specimen no longer retained an odor upon completion of the analysis. These data suggested that the off-odors are caused by two general classes of compounds: (a) a highly volatile, permanganate oxidizable substances, i.e., VRS; and (b) a less volatile, non-oxidizable substance.

In the case of VRS development in frankfurters (Figure 5), those without cure exhibited VRS maxima after six days storage whereas those with cure showed an increase after 16 days. The incorporation of ascorbate in the frankfurters had little or no influence upon VRS formation in cured frankfurters. All samples showed a fluctuation of VRS with storage time. These maxima and minima in the curves may be due to variations in the sample, and/or secondary oxidative phenomena.

Other investigators (Maier and Tappel, 1959, 1959a) have demonstrated that fat oxidation is catalyzed by heme compounds; however, cured meat pigments are non-catalytic (Younathan and Watts, 1960). The rate of VRS formation in the cured versus uncured frankfurters are suggestive of this type of heme catalyzed fat oxidation as a contributing factor to VRS development.

THIOBARBITURIC ACID TEST

Introduction. The reaction of 2-thiobarbituric acid (TBA) with the oxidation products of unsaturated fatty acids to produce a red pigment has been considered as an objective means for following deterioration of food substances (Turner, et al., 1954; Caldwell and Grogg, 1955; Yu and Sinnhuber, 1957). It has been suggested that the red pigment is produced by the reaction of TBA with malonaldehyde and the use of 1, 1, 3, 3, tetra-ethoxypropane (TEP) as a standard was proposed by Sinnhuber and Yu (1958). Malonaldehyde is formed from TEP by hydrolysis. Tarladis, et al., (1960) reported on a distillation procedure for the recovery of malonaldehyde from meat products, since evidence had been reported (Tims and Watts, 1958; Turner, et al., 1954; Schwartz & Watts, 1957) to indicate that TBA brings about considerable oxidation in the presence of the test food substances.

Experimental. The distillation method was used in our initial studies for the objective determination of oxidative rancidity. Repeated recovery tests of known quantities of TEP and in the presence of meat or sausage are summarized below:

Substrate + TEP (moles)	% Recovery
Undistilled $5x10^{-8}$	99.6
Distilled $5x10^{-8}$	71.6
Distilled $5x10^{-8}$	63.0
Distilled $5x10^{-7}$	67.2
Distilled $5x10^{-7}$	46.6
Pork jowls + $5x10^{-7}$	49.0
*Frankfurters + $5x10^{-7}$	45.6
*Frankfurters + $5x10^{-7}$	44.7
*Frankfurters + $5x10^{-7}$	41.9

* Greiss reagent used to prevent interference with nitrite.

The data indicate considerable variation in TEP recovery and particular lack of TEP recovery in combination with meat or frankfurters.

On basis of the above results and findings of others (Tarladis, et al., 1960), we extended our work to include the effect of pH on TEP recovery. The results of these tests are tabulated below. In each case, $5x10^{-7}$ moles TEP were added to the distillation flask.

pH	Substrate	% Recovery Trial I	Trial II
0.05	TEP	57.8	-
1.0	TEP	62.8	60.4
1.5	TEP	67.2	63.8
1.75	TEP	64.7	-
2.00	TEP	68.8	58.3
3.0	TEP	-	50.9
5.2	TEP	-	79.4
1.0	Jowls + TEP	94.0	
1.5	Jowls + TEP	65.2	
2.0	Jowls + TEP	72.0	
3.0	Jowls + TEP	68.6	
5.2	Jowls + TEP	73.0	

The data indicate some lack in reproducibility and an inconsistency in the effect of pH on TEP recovery.

Caldwell and Grogg (1955) reported that the formation of interfering yellow compounds with TBA, when testing other than pure fats, may be circumvented by chromatographic separation of the yellow and red compounds. When we applied their method, TEP recovery from a standard was reproducible and of a possibly higher magnitude when added to meat samples than was attainable by the distillation method. Partial results are summarized below.

Substrate	% Recovery
Ground beef + TEP (12×10^{-8} moles)	72.6
Ham trimmings + TEP (4×10^{-8} moles)	83.7
Ham trimmings + TEP (8×10^{-8} moles)	81.2
Ham trimmings + TEP (16×10^{-8} moles)	73.5

ACCELERATED STORAGE TESTS

Methods. In order to speed up product deterioration, cans containing frankfurters packed in a nitrogen or oxygen atmosphere were incubated at 37°C up to 90 hours. Samples were withdrawn after various incubation times and analyzed for VRS and TBA number. The results are summarized in Figures 6 and 7.

Results. Generally, the VRS content of franks canned under nitrogen increased with incubation times up to 90 hours (Figure 6) without showing signs of reaching a constant level. For any given period, there was essentially no difference in VRS content between the 40/60 and 60/40 frankfurters. Incubation of franks canned under an oxygen atmosphere resulted in more rapid VRS development and after 64 hours incubation reached a level 70% higher than that obtained during the corresponding incubation time of frankfurters canned under nitrogen. High levels of VRS could not be detected in the ground frank samples incubated in cans.

During incubation there was no increase in the TBA number of the frankfurters canned under nitrogen (Figure 7). The TBA numbers after 90 hours incubation appear to be smaller than those obtained initially.

STORED TEST SAMPLES

Methods. Frankfurters were made and packaged in tin cans and flexible pouches (mylar-polyethylene laminate) and stored in a 0° to $-10^{\circ}F$ freezer. Pouches and cans were sealed under vacuum, and after being flushed with nitrogen gas. This packaging procedure was followed for product manufactured from two formulations with different ratios of beef to pork, 60/40 and 40/60, respectively. Samples were withdrawn at 30 day intervals and tasted by a panel. A 9 point hedonic scale was used to express their evaluation. The VRS generated during storage and the TBA numbers of the corresponding samples tasted by the panel also were determined. Sulfanilic acid was added to nullify the effect of nitrite on the TBA values. This procedure was repeated three times. On the third test, no pouches were used for packaging; however, a batch of each type emulsion was vacuum chopped in addition to the normal chopping procedure. The panel scores were averaged and are summarized along with the VRS and TBA data in the tables on pages 17, 18, and 19.

Results

Test I. The panel scores indicate the quality of all the frankfurters deteriorated during frozen storage. There was no apparent difference between the 60/40 and 40/60 frankfurters. The canned samples were rated higher throughout the course of the storage period than were the flexible packaged samples. But no difference existed between samples maintained in a nitrogen or vacuum atmosphere. At the end of 6 months storage the panel commented that the frankfurters were quite rancid and not very acceptable; nonetheless, their scores did not completely reflect their comments.

Test II. While the initial panel scores were quite acceptable the panel scores dropped considerably after 1 month for the 40/60 packaged frankfurters and after 3 months for all but the 60/40 canned samples. After 2 months the 40/60 vacuum packaged frankfurters were rated too rancid to serve the panels while after three months the 40/60 nitrogen packaged frankfurters were too rancid for taste testing. No sampling was done at 4 months but by the time of the 5 month testing period the 60/40 packaged frankfurters, both vacuum and nitrogen packed, were too rancid for taste testing. The 60/40 and 40/60 canned frankfurters were tasted at 5 months. The 40/60 samples were rated quite low and the panel commented that the frankfurters were quite rancid. The 60/40 cans rated superior to any of the other samples, but the relatively high panel scores notwithstanding, the frankfurters were said to be quite rancid by the panel.

Test III. The low initial panel scores indicate the frankfurters were not of especially high quality when freshly made. These low initial scores may suggest why the panel ratings are so erratic from sample to sample and from month to month. The panel indicated they thought all the frankfurters showed some sign of rancidity development after the first couple of months storage even though their panel scores do not necessarily reflect this. There seemed to be a tendency on the part of the panel members to refrain from rating the frankfurters lower than about 3 on the hedonic scale no matter how rancid they became. Since the initial average panel scores did not exceed 6, this left little room to develop a perceptible trend during storage. By the fifth month the panel commented that all samples were quite rancid, although the scores would indicate they thought they detected differences in the degree of rancidity developed by the various samples. There was no statistically significant difference between the 60/40 and 40/60 formulations nor between the nitrogen flushed and vacuum cans. But there was a statistically significant difference between the vacuum chopped and non-vacuumed chopped samples, with the vacuum chopped samples scoring higher than the non-vacuum frankfurters.

TEST I

Meat Block	Package	Atmosphere	Measurement	Storage Time (Months) 0	1	2	3	4	5	6	7
60 Beef/40 Pork	Can	Vacuum	Taste Panel	6.8	5.5	6.6	6.2	5.7	5.0	4.6	R*
			VRS	38	43	37	77	118	109	55	67
			TBA	3.00	2.16	2.27	2.39	2.10	2.58	2.68	6.04
60 Beef/40 Pork	Can	Nitrogen	Taste Panel	6.8	4.8	6.1	5.5	6.2	5.5	4.4	R*
			VRS	38	78	72	71	189	98	42	97
			TBA	3.00	2.32	2.37	2.13	2.30	1.91	1.98	6.76
60 Beef/40 Pork	Film	Vacuum	Taste Panel	6.8	4.4	4.7	4.5	3.6	3.4	3.2	R*
			VRS	38	40	49	110	124	86	66	91
			TBA	3.00	2.17	3.10	2.96	3.30	8.50	7.04	11.70
60 Beef/40 Pork	Film	Nitrogen	Taste Panel	6.8	4.8	4.7	3.5	4.6	3.8	4.4	R*
			VRS	38	65	62	73	113	94	39	87
			TBA	3.00	3.10	2.30	3.97	3.07	6.48	4.32	9.44
40 Beef/60 Pork	Can	Vacuum	Taste Panel	7.0	4.8	6.2	5.9	5.2	3.2	3.1	R*
			VRS	26	75	39	86	82	86	67	96
			TBA	2.82	2.72	2.90	2.23	2.65	3.28	3.97	6.93
40 Beef/60 Pork	Can	Nitrogen	Taste Panel	7.0	6.8	6.3	4.4	4.4	4.5	4.2	R*
			VRS	25	44	38	47	94	164	43	100
			TBA	2.82	2.55	1.74	1.92	2.76	2.33	3.85	6.76
40 Beef/60 Pork	Film	Vacuum	Taste Panel	7.0	4.0	4.1	4.5	4.1	3.9	4.2	R*
			VRS	26	66	52	106	99	93	51	86
			TBA	2.82	3.46	2.86	3.03	2.86	4.60	6.97	7.70
40 Beef/60 Pork	Film	Nitrogen	Taste Panel	7.0	6.5	5.6	4.8	4.4	4.3	3.8	R*
			VRS	25	43	42	59	84	147	44	82
			TBA	2.82	2.20	2.35	2.03	3.07	2.72	6.64	13.25

* Rancid samples

TEST II

TEST II

Meat Block	Package	Atmosphere	Measurement	Storage Time (Months) 0	1	2	3	4	5
60 Beef/40 Pork	Can	Vacuum	Taste Panel	7.2	7.0	7.2	7.2	-	4.8
			VRS	78	99	82	95	60	57
			TBA	2.95	2.79	2.86	4.20	-	4.88
60 Beef/40 Pork	Can	Nitrogen	Taste Panel	7.2	7.4	6.8	7.2	-	5.8
			VRS	78	145	122	125	162	86
			TBA	2.95	3.38	2.72	3.98	-	3.55
60 Beef/40 Pork	Film	Vacuum	Taste Panel	7.2	6.6	7.2	3.4	-	R*
			VRS	78	96	101	83	46	53
			TBA	2.95	3.03	3.87	4.88	-	5.37
60 Beef/40 Pork	Film	Nitrogen	Taste Panel	7.2	6.8	6.2	6.0	-	R*
			VRS	78	96	101	83	46	53
			TBA	2.95	3.03	3.87	4.88	-	5.37
40 Beef/60 Pork	Can	Vacuum	Taste Panel	7.0	7.2	7.2	5.0	-	2.4
			VRS	46	102	75	83	54	185
			TBA	2.53	3.03	2.72	3.52	-	3.83
40 Beef/60 Pork	Can	Nitrogen	Taste Panel	7.0	6.6	6.8	4.0	-	2.8
			VRS	46	103	83	74	74	44
			TBA	2.53	3.00	3.70	3.59	-	3.98
40 Beef/60 Pork	Film	Vacuum	Taste Panel	7.0	3.2	R*	R*	-	R*
			VRS	46	93	60	-	-	-
			TBA	2.53	3.70	-	-	-	-
40 Beef/60 Pork	Film	Nitrogen	Taste Panel	7.0	4.6	5.4	R*	-	R*
			VRS	46	112	62	-	-	-
			TBA	2.53	3.52	4.33	-	-	-

* Rancid samples

TEST III

Meat Block	Vaccum Chopping	Can Atmosphere	Measurement	Storage Time (Months) 0	1	2	3	4	5
60 Beef/40 Pork	-	Nitrogen	Taste Panel	5.6	5.2	2.8	4.2	5.0	3.2
			VRS	88	143	170	155	158	145
			TBA	2.93	2.58	3.42	2.68	3.20	4.19
	+	Nitrogen	Taste Panel	5.6	6.0	3.4	4.6	6.6	4.6
			VRS	71	148	152	139	95	134
			TBA	2.26	2.51	3.07	2.44	3.08	3.84
60 Beef/40 Pork	-	Vacuum	Taste Panel	5.6	6.4	5.6	4.2	5.2	3.6
			VRS	88	168	105	135	83	103
			TBA	2.93	3.91	3.43	3.63	2.86	4.40
	+	Vacuum	Taste Panel	5.6	5.8	5.8	5.2	6.0	4.8
			VRS	71	196	94	100	84	86
			TBA	2.26	3.35	2.75	3.25	3.28	3.87
40 Beef/60 Pork	-	Nitrogen	Taste Panel	4.6	4.8	2.4	4.4	5.0	3.0
			VRS	78	118	133	132	104	142
			TBA	2.65	2.68	2.79	2.82	3.10	4.89
	+	Nitrogen	Taste Panel	5.0	6.4	4.4	5.6	6.8	4.6
			VRS	99	124	102	73	82	91
			TBA	2.47	2.62	2.58	3.14	3.10	4.05
40 Beef/60 Pork	-	Vacuum	Taste Panel	4.6	5.4	5.6	4.2	3.2	2.8
			VRS	78	153	93	122	106	107
			TBA	2.65	2.58	3.14	3.28	2.65	4.75
	+	Vacuum	Taste Panel	5.0	5.4	6.2	6.0	5.4	5.4
			VRS	99	167	97	184	86	93
			TBA	2.47	3.07	3.17	3.31	3.31	3.63

For each test the initial VRS values for the 60 beef/40 pork formulations were higher than for the high pork products. The VRS generated during storage reached a maximum between 1-5 months' storage. The values oscillated between the highs and lows, but at no time showed signs of levelling off. No consistent pattern was observed between the VRS generated and the shelf-life of the frankfurters.

The TBA values tended to increase during the storage of the frozen frankfurters. High values usually were associated with rancid samples; however, there were no indications that the TBA values signalled the onset of product deterioration.

CONCLUSIONS

Several approaches were investigated for predicting the shelf life of frankfurters stored at 0°F. These included; (a) the use of prooxidants, (b) determination of volatile reducing substances (VRS), and (c) evaluation of rancidity by the thiobarbituric acid test (TBA).

The work conducted on the use of prooxidants as a means for predicting the shelf life of frozen frankfurters indicated that the use of drier and ultra-violet radiation showed little promise in determining differences in the degree of rancidity inherent in both fresh and cured meat samples.

Technics for recovering the VRS were evaluated. Flushing the meat sample with nitrogen offered a rapid means for such recovery. During the course of this work, data were collected which suggested that off-odors produced during frankfurter deterioration are due to a highly volatile fraction that can be oxidized by permanganate, and a less volatile, non-oxidizable fraction. The rate of VRS formation is inhibited by meat curing salts.

In conjunction with the TBA test, comparisons were made of the distillation and chromatographic technics for recovery of the TBA reaction compound. The latter method seemed to offer more promise for the determination of TBA values in meat samples.

Two types of frankfurters (60 beef/40 pork and 40 beef/60 pork) were packaged in cans and pouches under vacuum and nitrogen atmosphere. The samples were stored in a freezer and withdrawn monthly for testing. This procedure was repeated three separate times (see page 2a for frankfurter composition). On the third time the product was canned and not packaged in film. For the third test, some emulsion was vacuum chopped in addition to the normal comminuting procedure.

Initial panel scores indicated that the quality of the product was not consistent during each trial. Spoilage was apparent after 2-3 months storage. High beef frankfurters did not necessarily have a longer shelf-life than the high pork frankfurters. Vacuum chopped product was more acceptable than that which was non-vacuum chopped. Canning was somewhat superior to packaging in flexible film. However, vacuum packaging seemed to have no advantage over nitrogen packing.

Attempts were made to accelerate storage conditions in conjunction with developing a test method for predicting the shelf-life of frozen frankfurters. Although the VRS content of frankfurters increased slightly during accelerated storage, the TBA values declined slightly. Consequently, the measurement of VRS was thought to be more indicative of organoleptic frankfurter deterioration than the TBA number.

However, VRS values and TBA numbers did not signal frankfurter spoilage at the times indicated by the taste panel. This made it impractical to follow either measurement as a means for predicting shelf-life.

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Fig. 1. Apparatus for the determination of Volatile Reducing Substances (VRS) in Meat.

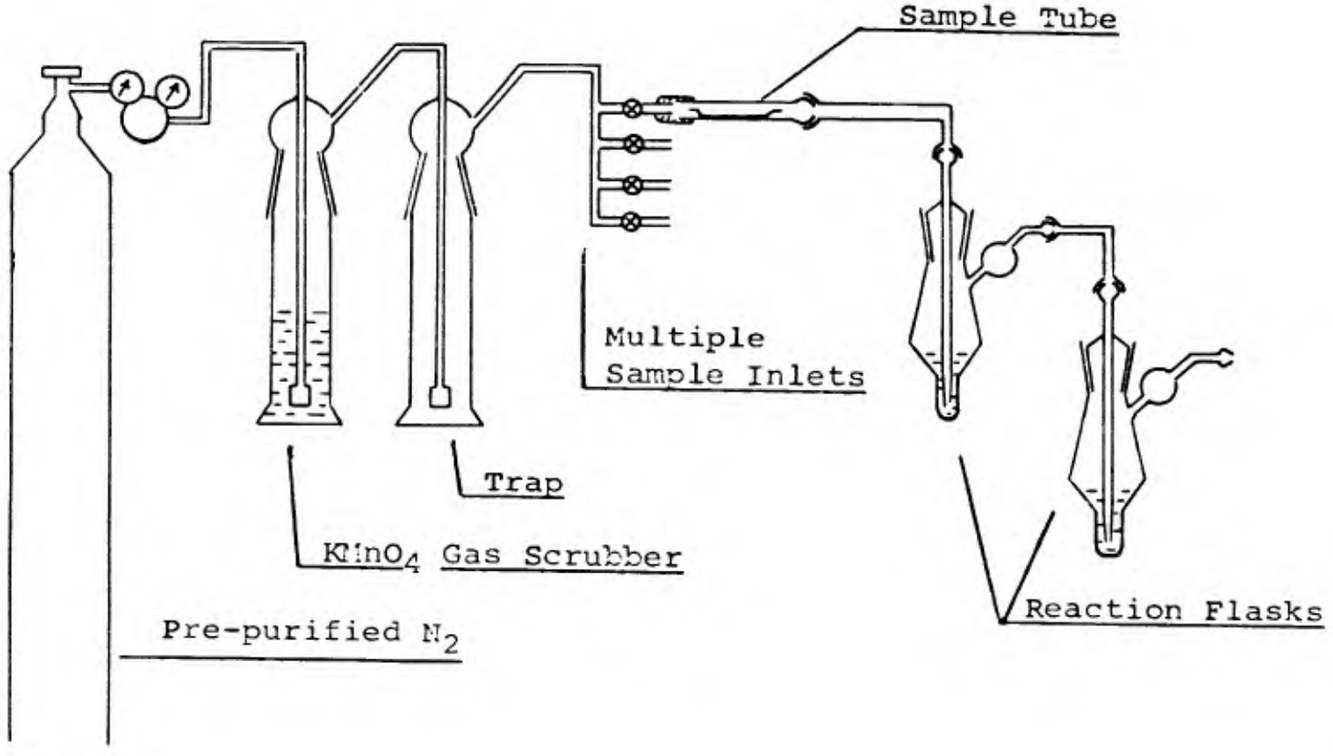


Fig. 2. Recovery of Volatile Reducing Substances (VRS) from Ground Beef Chuck as a function of Sample Weight, Sample Temperature and Purging (N_2) Time.

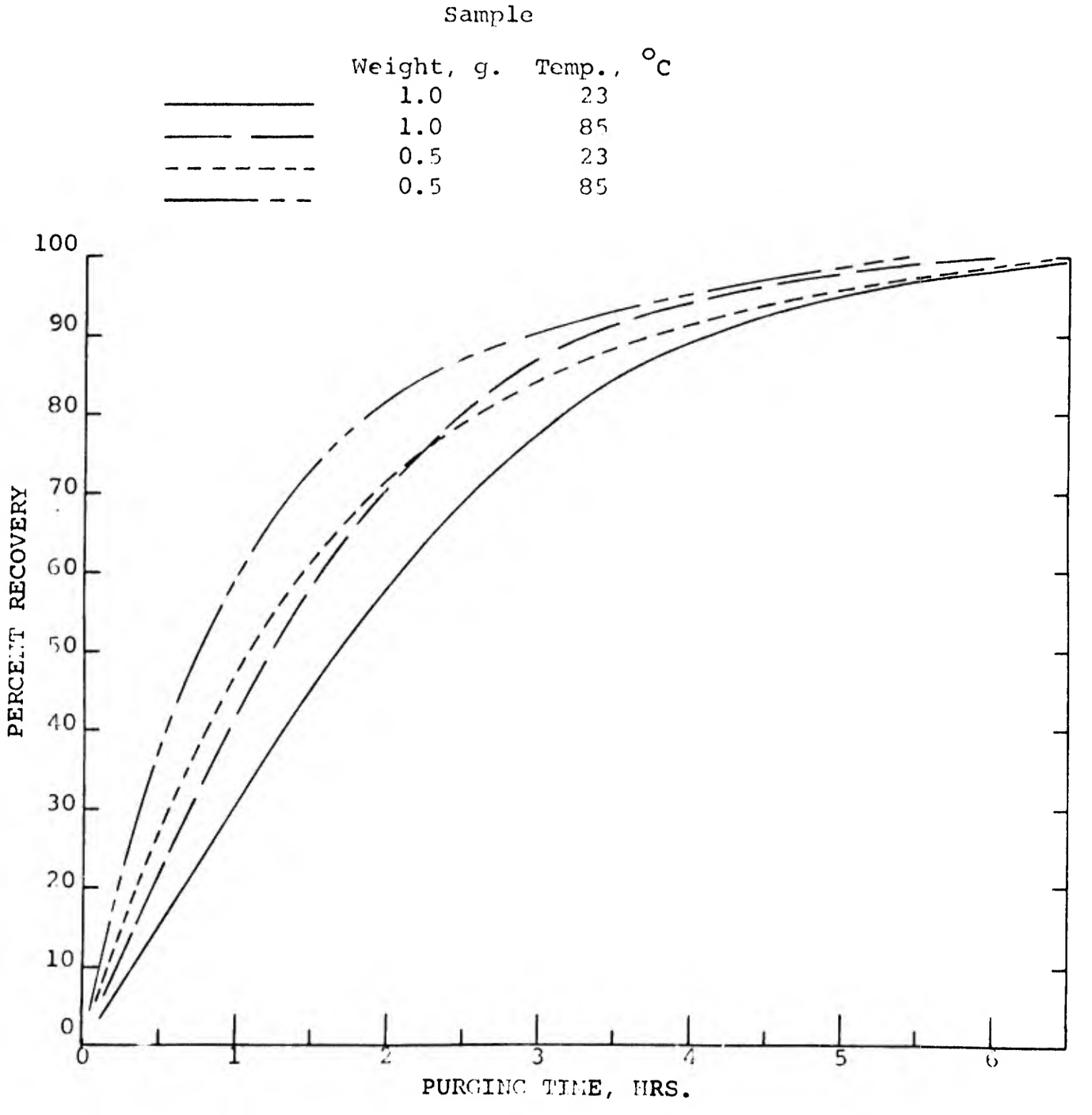


Fig. 3. Recovery of Volatile Reducing Substances (VRS) from 1.0 gram frankfurter samples as a function of sample temperature and purging (N_2) time.

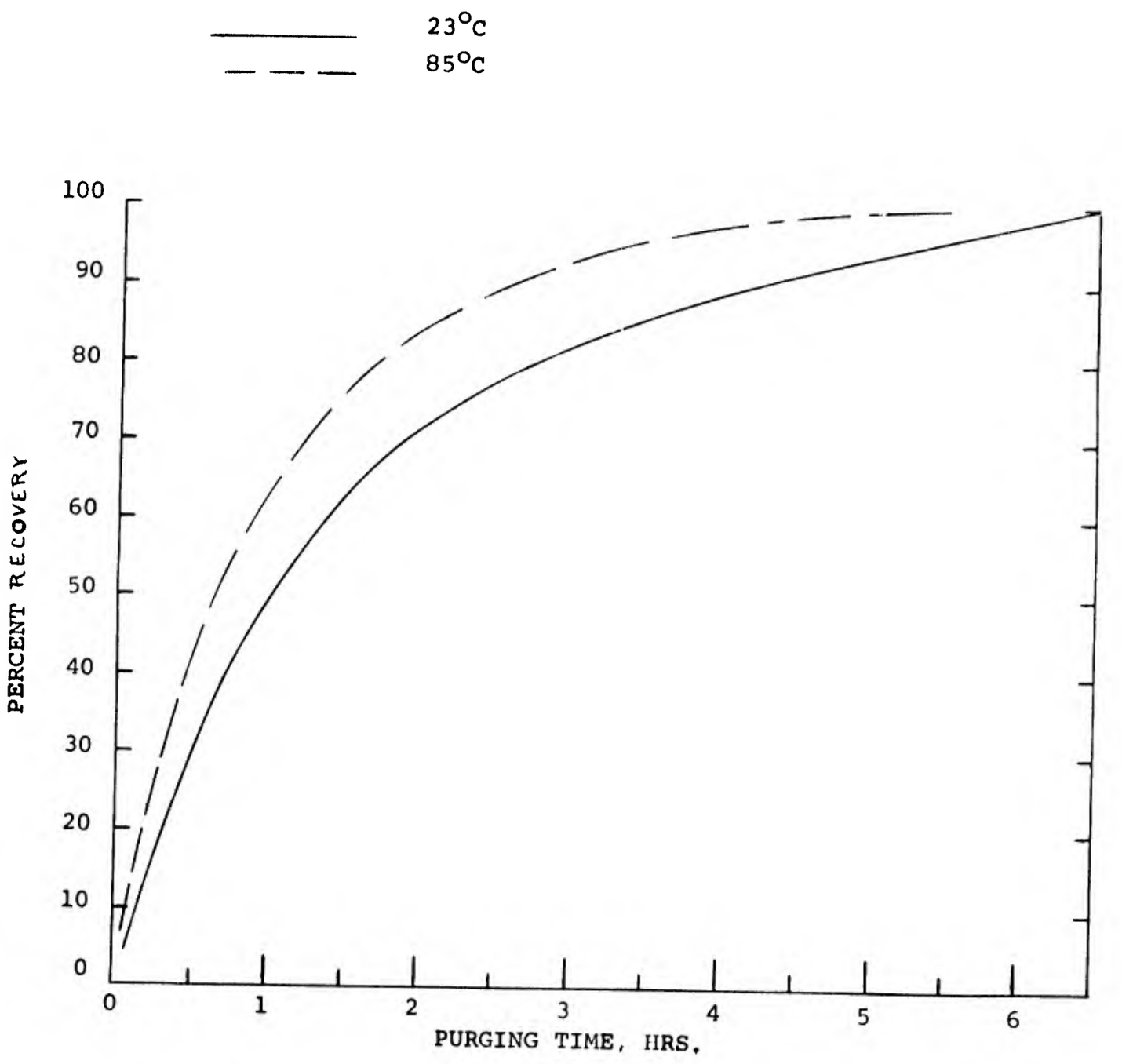


Fig. 4. Development of VRS in Ground Beef Chuck as a function of storage time at 40°F.

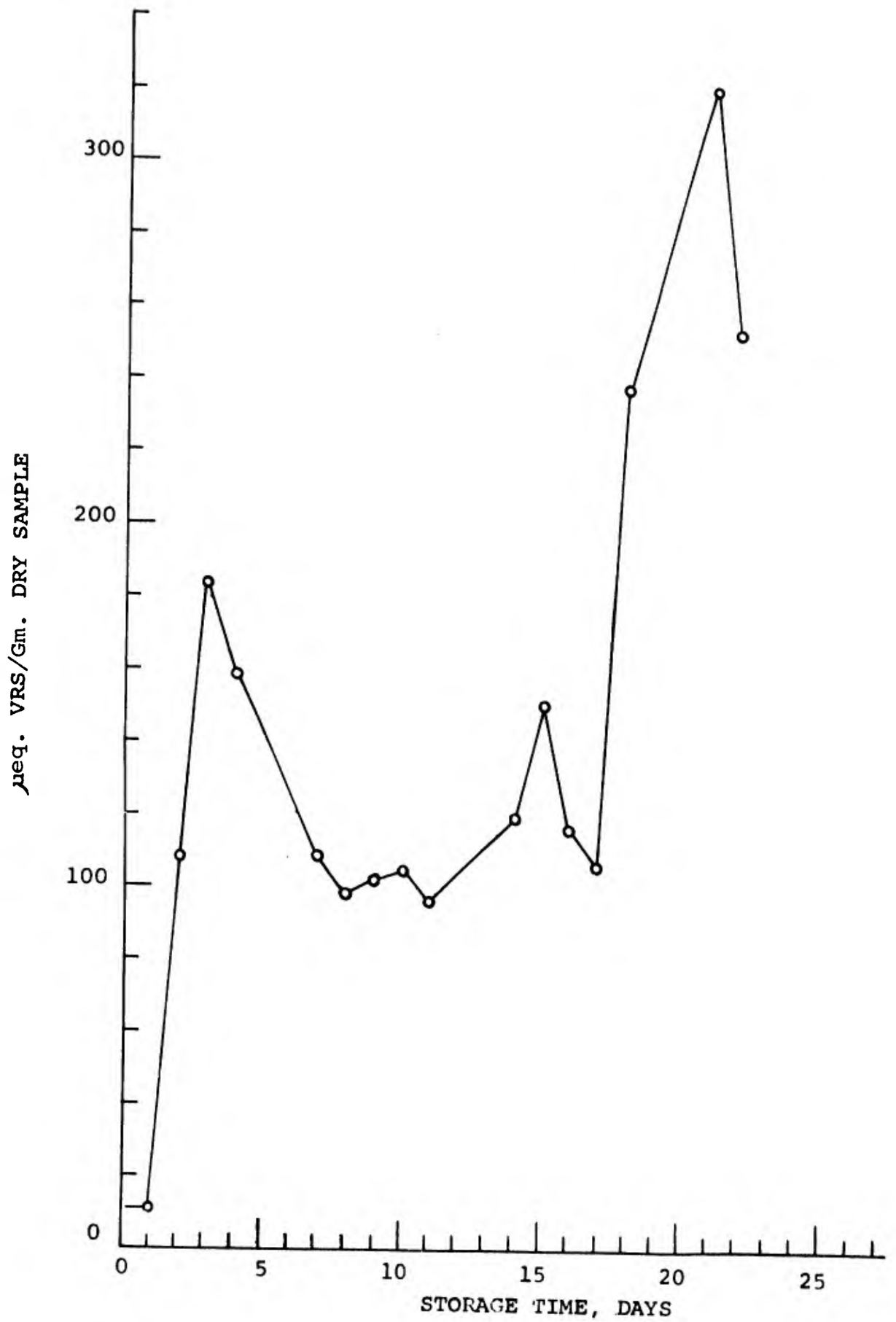


Fig. 5. Development of VRS in Ground Frankfurters as a function of Storage Time at 40°F.

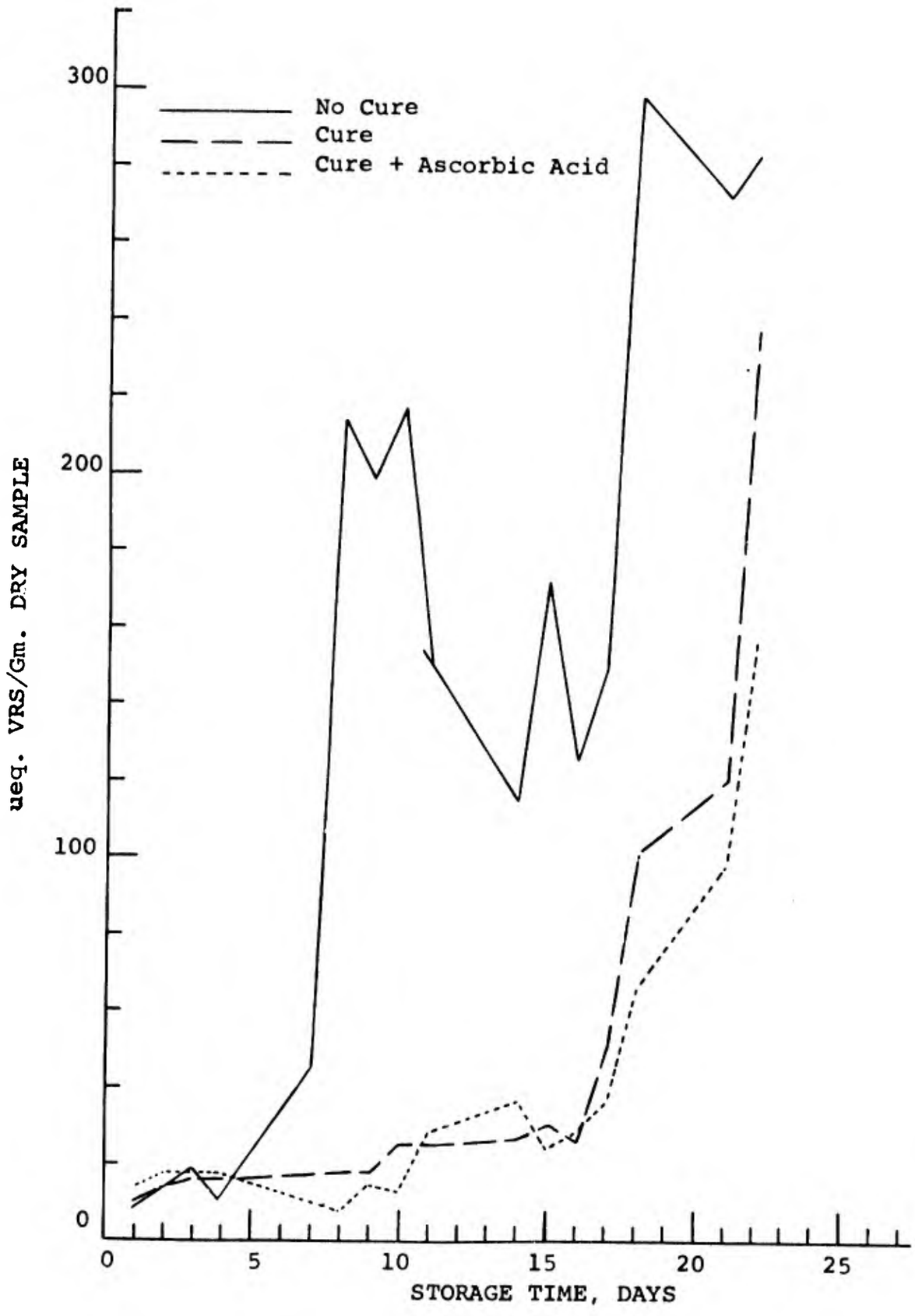


Fig. 6

Influence of Incubation Time on the Development of VRS in Canned Frankfurters

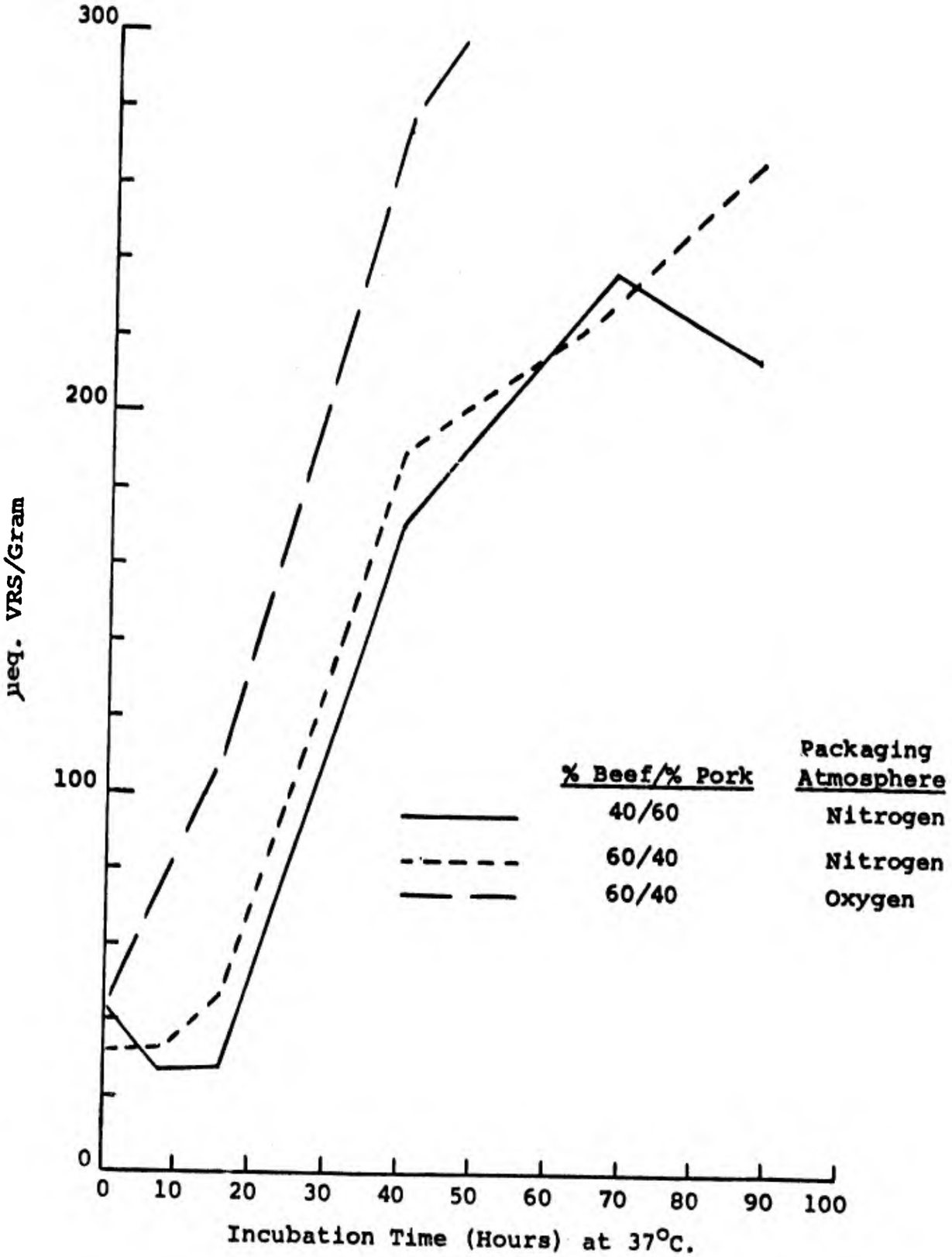
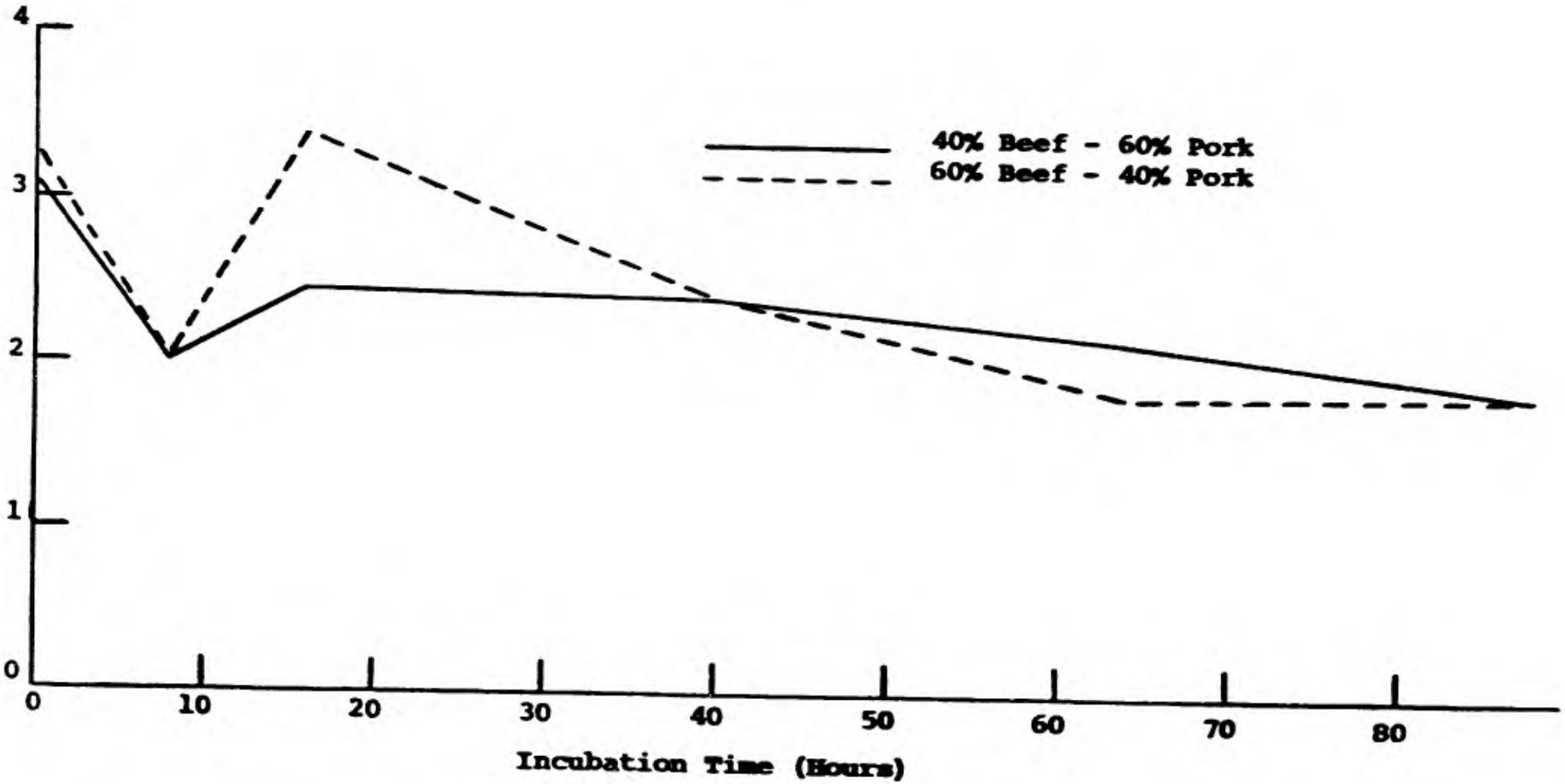


Fig. 7

Influence of Incubation Time on the
TBA Number of Frankfurters Canned
in Nitrogen Atmosphere



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13 ABSTRACT

Frankfurters prepared in accordance with standard commercial formulations and processes simulated the rancidity pattern observed under field conditions. Some experimental lots were evaluated as rancid after 2 to 3 months storage at 0 to -10°F; other lots were found to be free of rancidity after 6 months. Experiments involving the use of prooxidants or exposure to ultraviolet radiation showed no promise of differentiating between frankfurters undergoing rapid and slow oxidative changes during frozen storage. Observations were performed on the suitability of the thiobarbituric acid (TBA) test and on the determination of volatile reducing substances (VRS) to the identification of frankfurters predisposed to rapid development of rancidity. Neither of these tests, even when used in conjunction with accelerated storage conditions, was found suitable for predicting the onset of rancidity during frozen storage.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Rancidity	8		9			
Storage stability	8		9			
Frankfurters	9		9			
Frozen	0		0			
Military rations	4					
Prediction			8			
Thiobarbituric acid test (TBA)			10			
Volatile reducing substances (VRS)			10			
Ultraviolet radiation			10			
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