

TECHNICAL REPORT

69-54-FL

AD

**EFFECT OF HEADSPACE OXYGEN  
ON THE  
QUALITY OF FREEZE-DRIED RAW BEEF PATTIES**

by

J. M. Tuomy

and

L. C. Hinnergardt

November 1968

**UNITED STATES ARMY  
NATICK LABORATORIES  
Natick, Massachusetts 01760**



**Food Laboratory**

**FL-87**

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## FOREWORD

The adverse effect of oxygen in freeze-dried foods has been recognized since the beginning of the Armed Forces program to develop freeze-dried ration items. When the first limited procurements of the new foods were made, it was found that Industry did not have the facilities or experience to obtain oxygen levels approaching zero. However, it was established that a specification requirement of 2 percent maximum oxygen in the headspace gas was achievable. In-house storage studies, field tests, and field use have shown that this requirement results in products acceptable for Armed Forces use. However, foods are very complex and the response of foods to oxygen varies widely from item to item. Since packaging with low oxygen is expensive and is an inspection problem as well, studies on individual items are necessary to establish the oxygen "tolerance" of each item.

The study was undertaken to determine the effects of oxygen in freeze-dried raw beef patties as part of a larger study of both cooked and raw products. The work was performed under project 1J6-62708-D553, Food Processing and Preservation Techniques.

The work of Mr. Otto Stark and Mrs. Margaret Robinson, U. S. Army Natick Laboratories, in planning and conducting the chromatographic analyses for this study is gratefully acknowledged.

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## ABSTRACT

Freeze-dried raw beef patties were packed in cans with vacuums ranging from 30 to 0 inches and stored at 100°F. Cans were withdrawn from storage at intervals for 24 weeks and evaluated by a technological panel for flavor, odor, and texture. In addition, the headspace gas was analyzed for oxygen by chromatographic means and the rehydration ratio determined.

The oxygen uptake by the product correlated at the 1 percent level with flavor, odor, texture, and rehydration ratio of the product. Storage at 100°F was found to have more of an adverse effect on the organoleptic properties of the raw beef patties than it did with cooked combination items such as chili con carne, although the amount of oxygen originally present in the headspace also had a significant effect. Both storage and oxygen had a significant effect on the rehydration ratio of the beef pattie, whereas they did not with the cooked combination items as determined in other studies.

## Introduction

The adverse effects of oxygen uptake on the quality of freeze-dried foods have been noted by many investigators and have been of concern since the inception of the Armed Forces program for the development of new freeze-dried operational rations. Sharp (1953) and Harper and Tappel (1957) point out that dehydrated meat absorbs oxygen and should be kept in an oxygen-free atmosphere. Olcott (1962) states that there is a rapid loss in palatability when freeze-dried meat and fish are stored in oxygen or air. Wuhrmann et al. (1959) and Tappel et al. (1957) note that the storage stability of freeze-dried foods is improved when the foods are packed in a nitrogen atmosphere, but do not draw any conclusions as to a practical limitation on oxygen to insure stability. Thompson et al. (1962) state that three major factors determine the type and extent of deteriorative reactions in freeze-dried foods: residual moisture level; headspace oxygen content; and duration of storage at elevated temperatures. Roth et al. (1965) investigated the deterioration of freeze-dried beef, chicken, carrots, and spinach, reporting that exposure to oxygen appeared to be the most significant factor in degradation of freeze-dried products stored at elevated temperatures. Smithies (1962) states that in an oxygen-free atmosphere, freeze-dried meat products suffer only a slow change in quality over periods of several months and air storage of these products can bring about spectacular decreases in rehydration.

A large number of in-house storage studies, as well as large scale field tests have shown that most freeze-dried foods are sufficiently stable for military use if, among other things, the products are nitrogen packed with less than 2 percent oxygen in the headspace gas, or vacuum packed at 28 inches or better. However, the validity of absolute requirements of 2 percent oxygen or 28 inches of vacuum has not been established. Furthermore, it is known that freeze-dried foods vary in their susceptibility to oxidative deterioration. Therefore, this study was conducted to determine the effects of various amounts of oxygen on the acceptability and rehydration ratio of raw freeze-dried beef patties stored at an elevated temperature.

## Experimental Methods

The beef patties were made in accordance with Military Specification MIL-B-43143, Beef Patties, Dehydrated, Raw. The total amount of product needed for the investigation was made in a single run to minimize processing variations. Freeze dehydration was accomplished with radiant heating, (platen temperature of 120°F) and a pressure of 400 microns. Dehydration was to less than 2 percent moisture and the vacuum on the chamber was broken with nitrogen. Packaging was in No. 2½ cans and was accomplished within two hours after the dehydrator was opened.

Twenty-five cans each containing 125 grams of product were closed at each vacuum. Vacuums used were 30, 28, 26, 24, 22, 20, and 0 inches of mercury. The cans closed at 30 inches were evacuated three times with a 30 second dwell each time and flushed back with nitrogen the first two times. The other cans were closed as soon as the gauge indicated the required vacuum. The vacuums attained corresponded approximately to 0.3, 1.2, 2.8, 3.4, 4.9, 5.9, and 21 percent oxygen in the headspace at atmospheric pressure if the cans had been gas packed. The closed cans were stored at 100°F and 5 cans of each vacuum were withdrawn for evaluation at 0, 2, 4, 12 and 24 weeks.

The storage temperature was chosen as 100°F since one of the standard requirements used in the development of freeze-dried meat for military rations is that they must be acceptable after one year of storage at this temperature.

Headspace gas analysis was performed by chromatographic means in accordance with the procedure outlined by Bishov and Henick (1966). Prior to analysis the cans were brought to room pressure with nitrogen and allowed to equilibrate overnight. Sample size was 250-500  $\mu$ l. Experience with this method in-house indicates an anticipated error for the method of approximately  $\pm$  0.25 percent. Results for the 5 cans at each level were averaged for reporting purposes.

Total headspace volume in the can was determined by compressing 125 grams of the product in a laboratory press at 5,000 lbs/sq. in. with a 10 second dwell time, and subtracting the volume of the resulting bar from the total volume of the can. It was recognized that this method is not the most accurate available, but considering that the volume of the headspace was so large in comparison with the absolute volume of the product and that evaluations were made by a taste panel, any resulting error was considered insignificant.

Products to be evaluated by the panel were rehydrated for 10 minutes in an excess of 80°F water, drained, and then fried for 2 minutes per side on a grill at 400°F. It was found necessary to rehydrate the 24-week samples for 30 minutes rather than 10 minutes to obtain complete water penetration. Taste panel evaluations were made by a 10-member technological panel rating the product on a 9-point scale for flavor, odor, and texture where the highest number was the most acceptable for flavor, odor, or texture. The same panel members were used for each evaluation. Product in the cans used for chromatographic analyses was used for the panel evaluation.

The rehydration value was obtained by rehydrating 100 grams of product in an excess of water for 10 minutes, draining the product for one minute on a wire screen, and reweighing. In this case, 24-week products also were rehydrated for 10 minutes rather than for 30 minutes as was the case when they were submitted to the taste panel. Rehydration ratio was calculated as weight of rehydrated product divided by weight of the dry product.

## Results and Discussion

Table 1 shows the oxygen uptake and the results of the panel evaluation. Table 2 indicates the rehydration ratios. Table 3 shows the analysis of variance results for the effect of the variables on organoleptic properties and rehydration.

The results of the analysis of variance confirm that oxygen and storage time at elevated temperatures are two important factors in determining the deterioration of freeze-dried foods (Thompson *et al.*, 1962; Tuomy *et al.*, 1968). However, comparison of these results with unpublished in-house data for eight precooked dehydrated combination items such as chili con carne show several differences. With the raw beef pattie, the results for odor rating were not as clearcut as the results for flavor and texture. With the precooked combination items, the results for texture

were not as clearcut as those for flavor and odor. In both cases, however, flavor was the controlling attribute with significant decreases in flavor rating occurring at higher vacuums and shorter storage times than was the case with either odor or texture. If the components of variance are calculated for flavor of the beef patties according to the method of Hicks (1956), it is found that vacuum accounted for only 7 percent of the variance and storage time about 35 percent. However, with cooked, freeze-dried spaghetti with meat sauce, for example, the percentages were about 34 percent for vacuum and only 19 percent for storage time. This would indicate that storage at elevated temperature is a more important source of variance with the raw beef patties than it is with the cooked spaghetti with meat sauce although both are important. Although there were some differences found in the components of variation of the various precooked combination items, in general they followed the same pattern as the spaghetti with meat sauce.

Analysis of variance for the rehydration ratio (Table 3) shows that vacuum, storage time at 100°F, and the vacuum X storage time interaction had effects significant at the 1 percent level. In this case, however, 87 percent of the variance was due to storage time, 2 percent to vacuum, and 3 percent to the interaction. Although the effect of vacuum was significant and cannot be ignored, almost all of the variation in the rehydration ratio was due to the storage at 100°F. This was confirmed by the fact that the product held at all vacuum levels for 24 weeks had to be held a longer time in the rehydration water to obtain penetration of the water.

It should be noted that the unpublished data for a similar study on eight precooked combination items show that there were no significant effects on rehydration ratio due to vacuum, storage at 100°F, or their interaction. On the other hand, informal observations made during many in-house storage studies of uncooked items such as beef patties and pork chops, have shown rehydration difficulties after periods of elevated temperature storage. This tends to confirm the results of this study on beef patties.

Table 4 shows the correlation coefficients for oxygen uptake vs. flavor, odor, texture, and rehydration ratios. All are significant at the 1 percent level. The coefficients indicate about 57 percent of the linear variation in flavor and 33 percent in rehydration ratios are accounted for by oxygen uptake.

The results of this study reemphasize the need for rigid oxygen control measures for packaging freeze-dried rations to be used by the Armed Forces. In addition, rehydration problems with uncooked meats due to both oxygen and storage factors indicate that more work is needed in elucidating the mechanisms of rehydration and changes in the products which cause rehydration problems.

TABLE 1. Organoleptic ratings of freeze-dried raw beef patties over a 24-week storage period at 100°F and oxygen uptake by 125 grams of product.

Vacuum (in.)	30			28			26			24			22			20			0			
	O <sub>2</sub> avail (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	
	3			10			22			26			37			45			162			
Time (wks)	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	O <sub>2</sub> up- take (ml)	fla- vor	tex- ture	
0	0	6.6	6.7	6.4	6.6	6.7	6.4	6.6	6.7	6.4	6.6	6.7	6.4	6.6	6.7	6.4	6.6	6.7	6.4	6.6	6.7	6.4
2	1	6.0	6.4	6.5	6.5	6.8	6.7	6.5	6.8	6.3	6.1	6.5	6.5	6.5	6.5	11	6.9	6.8	6.5	6.7	6.8	6.6
4	2	6.2	5.8	6.1	6.5	6.3	6.1	6.5	6.3	6.7	5.8	6.1	5.6	6.2	6.2	23	6.2	5.9	6.2	5.9	5.9	4.1
12	2	5.7	5.9	5.4	6.1	6.3	6.1	5.5	5.8	5.4	5.0	5.6	4.4	5.8	5.5	33	4.2	5.3	5.5	4.3	4.3	4.6
24	1	5.0	5.2	4.4	5.4	5.4	5.3	4.7	5.0	4.4	5.3	5.4	4.9	4.0	5.1	35	3.8	4.9	3.8	3.2	4.4	4.3

TABLE 2. Rehydration ratios of freeze-dried raw beef patties over a 24-week storage period at 100°F and oxygen uptake by 125 grams of product.

Vacuum (in.) O <sub>2</sub> available (ml)	30		28		26		24		22		20		0	
	O <sub>2</sub> uptake	ratio	O <sub>2</sub> uptake	ratio	O <sub>2</sub> uptake	ratio	O <sub>2</sub> uptake	ratio	O <sub>2</sub> uptake	ratio	O <sub>2</sub> uptake	ratio	O <sub>2</sub> uptake	ratio
0	0	2.270	0	2.270	0	2.270	0	2.270	0	2.270	0	2.270	0	2.270
2	1	2.308	6	2.300	12	2.227	9	2.206	11	2.234	10	2.250	26	2.182
4	2	2.289	9	2.228	18	2.223	14	2.216	23	2.021	23	2.052	49	1.983
12	2	2.162	8	1.919	20	1.914	23	1.742	33	1.846	40	1.801	82	1.757
24	1	1.361	9	1.342	20	1.549	25	1.286	35	1.341	43	1.397	114	1.341

TABLE 3. Analysis of variance results for effect of variables on organoleptic properties and rehydration ratio.

<u>Factor</u>	<u>Flavor</u>	<u>Odor</u>	<u>Texture</u>	<u>Rehydration ratio</u>
Vacuum	**	*	**	**
Storage time at 100°F	**	**	**	**
Vacuum X Storage Time	**	N.S.	**	**

\* - P < 0.05                      \*\* - P < 0.01                      N.S. - Not significant at P < 0.05

TABLE 4. Correlation coefficients (r) and regression equations for ml oxygen uptake (x) versus organoleptic properties and rehydration ratio (y).

<u>Variates</u>	<u>r values</u>	<u>Regression Equation</u>
Flavor rating	.7558**	Y= 6.26 - 0.031X
Odor rating	.6575**	Y= 6.27 - 0.018X
Texture rating	.5600**	Y= 5.98 - 0.023X
Rehydration ratio	.4759**	Y= 2.08 - 0.0068X

\*\*P < 0.01                      DF = <sup>2</sup>/<sub>7</sub>

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13. ABSTRACT

Freeze-dried raw beef patties were packed in cans with vacuums ranging from 30 to 0 inches and stored at 100°F. Cans were withdrawn from storage at intervals for 24 weeks and evaluated by a technological panel for flavor, odor, and texture. In addition, the headspace gas was analyzed for oxygen by chromatographic means and the rehydration ratio determined.

The oxygen uptake by the product correlated at the 1 percent level with flavor, odor, texture, and rehydration ratio of the product. Storage at 100°F was found to have more of an adverse effect on the organoleptic properties of the raw beef patties than it did with cooked combination items such as chili con carne, although the amount of oxygen originally present in the headspace also had a significant effect. Both storage and oxygen had a significant effect on the rehydration ratio of the beef patty, whereas they did not with the cooked combination items as determined in other studies.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Headspace	6					
Oxygen	6					
Freeze-dried foods	7, 4					
Beef	7					
Raw	0					
Acceptability	7					
Rehydration	7					
Flavor	7					
Odors	7					
Texture	7					
Storage	4					